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**Sogo et al.**

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(54) **LIGHT EMITTING DEVICE AND METHOD OF MANUFACTURING LIGHT EMITTING DEVICE**

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**Related U.S. Application Data**

(63) Continuation of application No. 14/821,369, filed on Aug. 7, 2015, now Pat. No. 9,559,006.

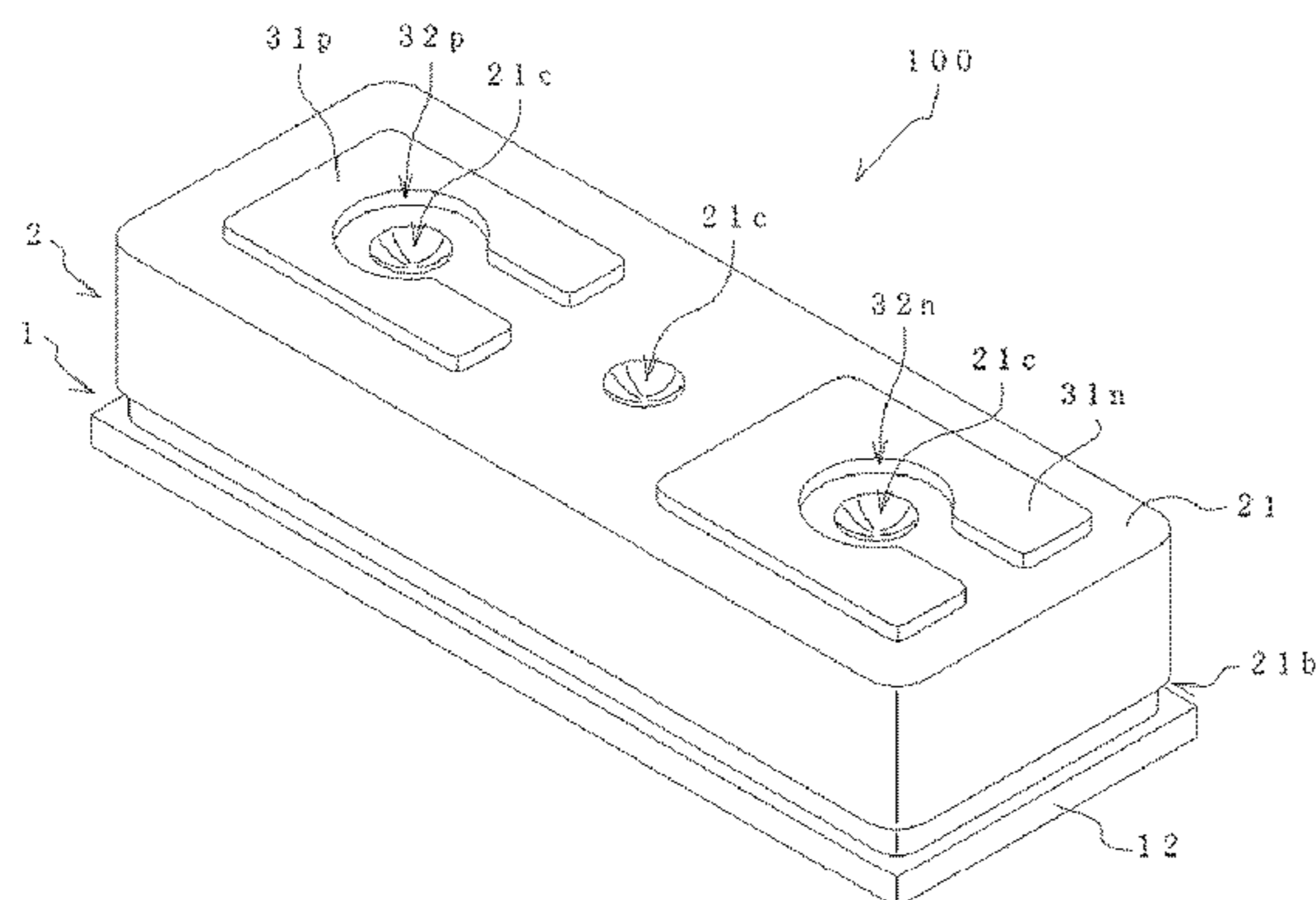
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**H01L 33/38** (2010.01)

(Continued)



(52) **U.S. Cl.**

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(58) **Field of Classification Search**

None  
See application file for complete search history.

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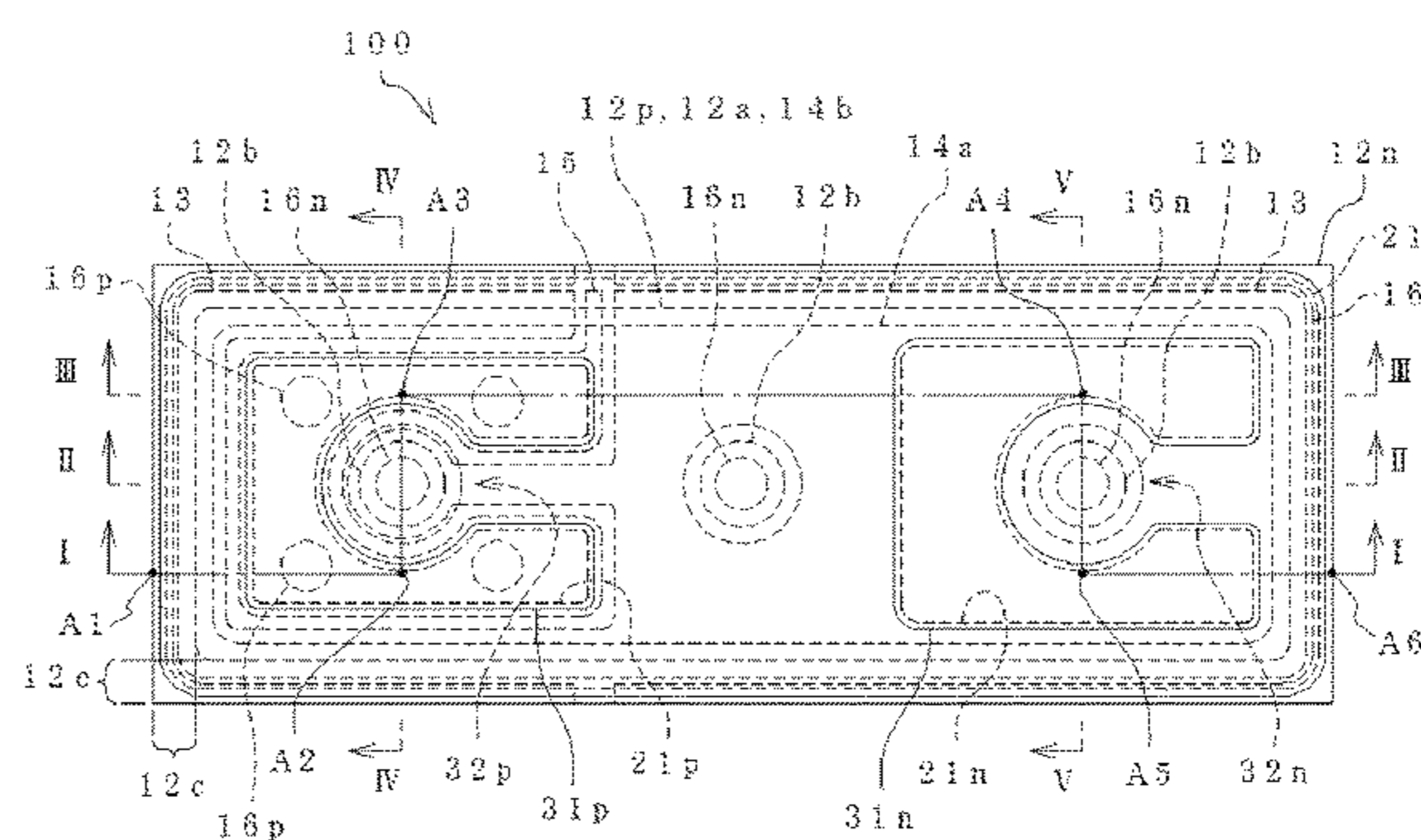
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(57) **ABSTRACT**

A light emitting device includes a semiconductor light emitting element including a semiconductor stacked-layer body and an electrode disposed on a first surface of the semiconductor stacked-layer body; a resin member disposed on a first surface side of the semiconductor stacked-layer body; and a metal layer disposed in the resin member and electrically connected to the electrode. A recess is defined in an upper surface of the resin member. The metal layer is projected from the upper surface of the resin member, and is disposed to surround at least a portion of the recess.

**14 Claims, 17 Drawing Sheets**



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*H01L 21/78* (2006.01)  
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*H01L 33/48* (2010.01)  
*H01L 33/56* (2010.01)  
*H01L 33/36* (2010.01)

(52) **U.S. Cl.**

CPC ..... *H01L 33/382* (2013.01); *H01L 33/405*  
(2013.01); *H01L 33/483* (2013.01); *H01L*  
*33/486* (2013.01); *H01L 33/56* (2013.01);  
*H01L 33/62* (2013.01); *H01L 33/48* (2013.01);  
*H01L 2933/005* (2013.01); *H01L 2933/0016*  
(2013.01); *H01L 2933/0033* (2013.01)

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FIG. 1A

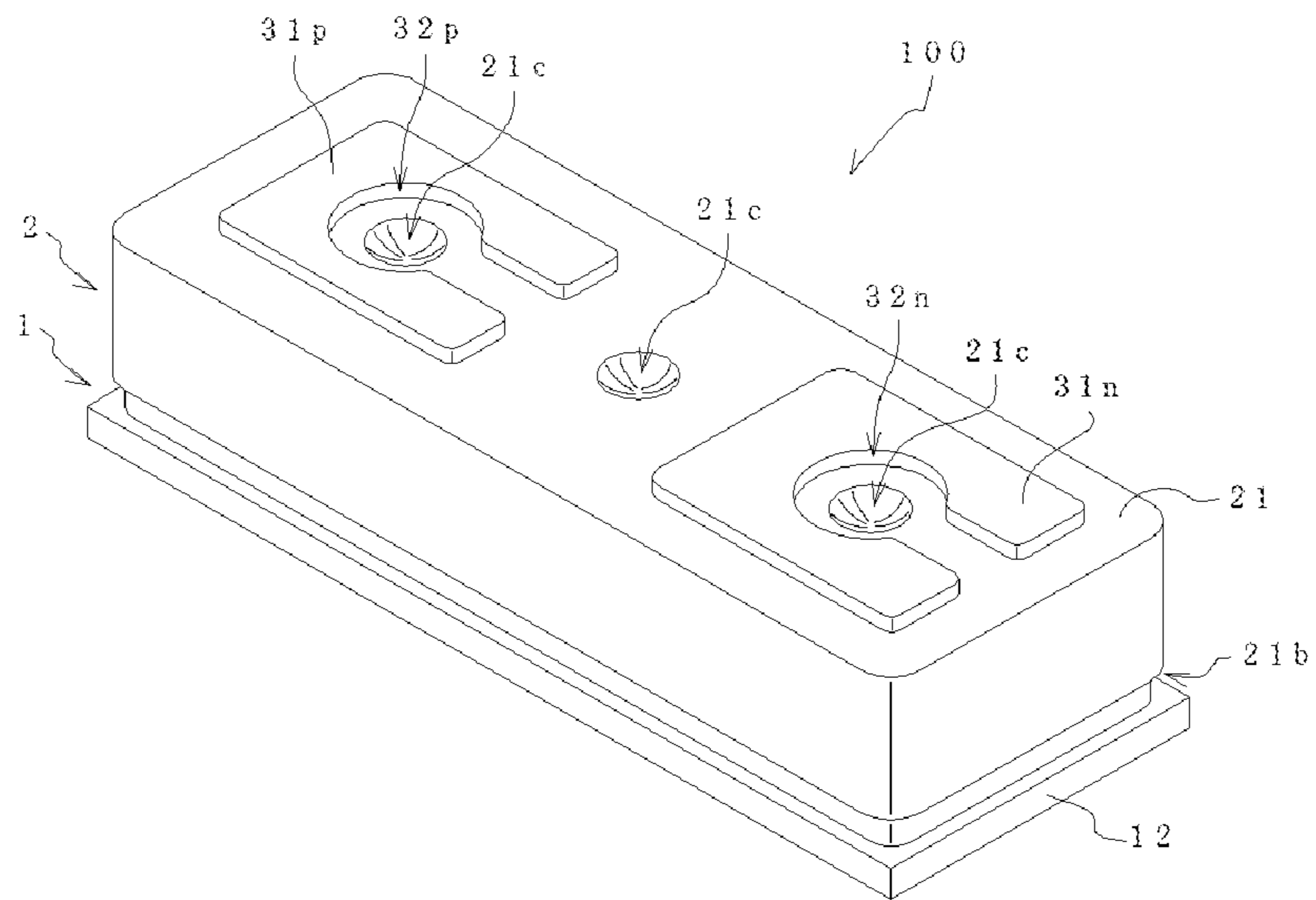


FIG. 1B

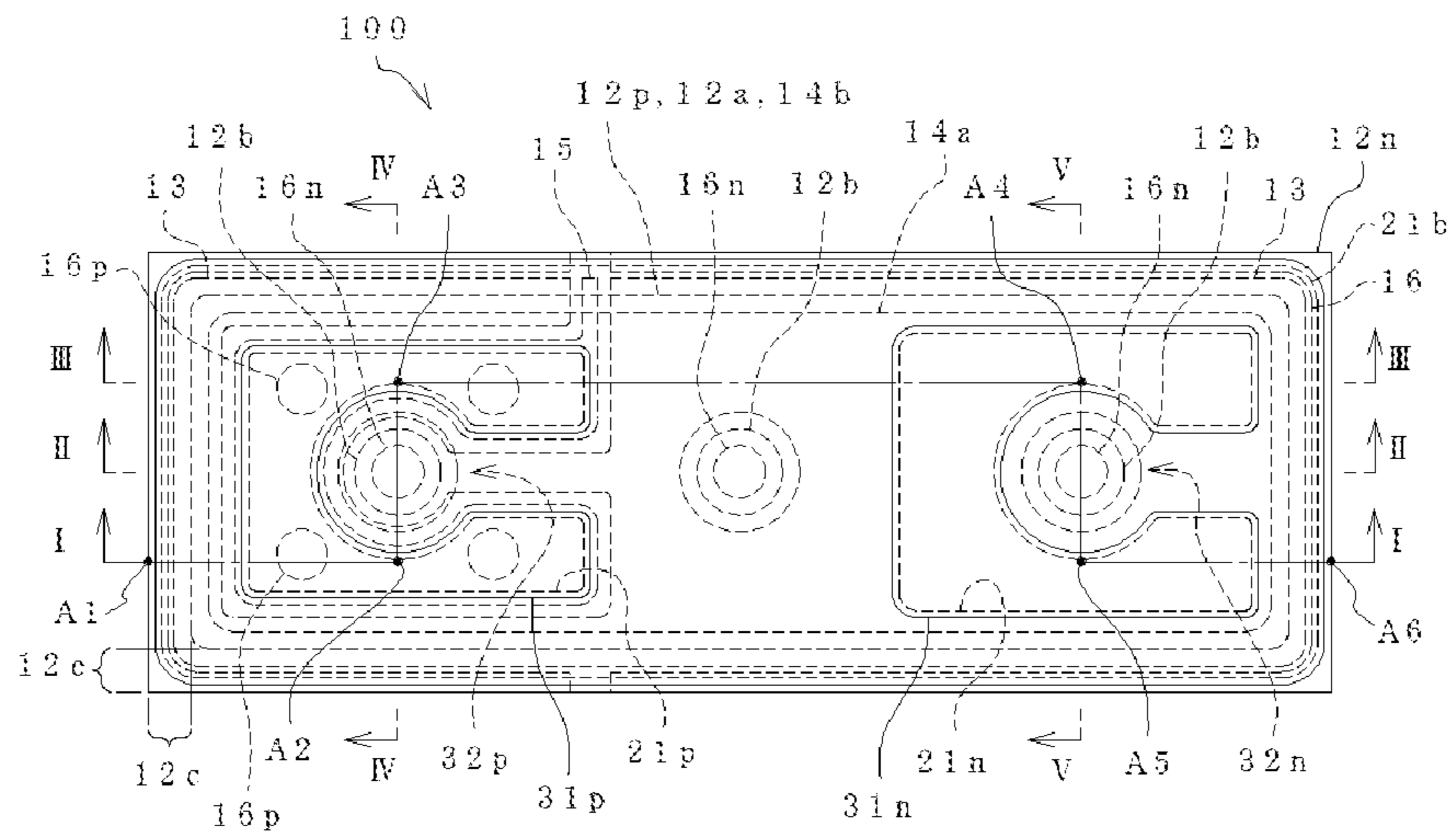


FIG. 2A

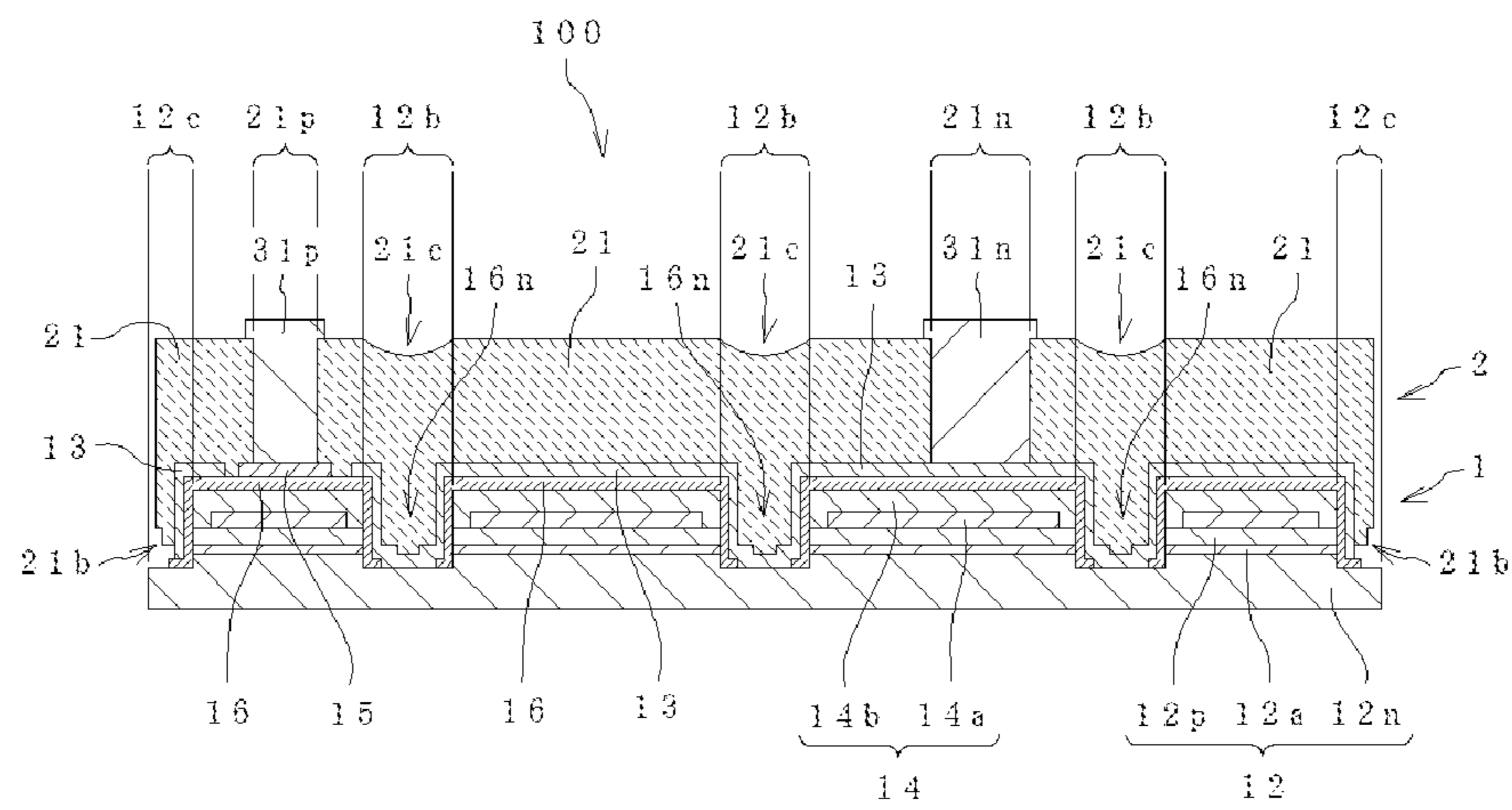


FIG. 2B

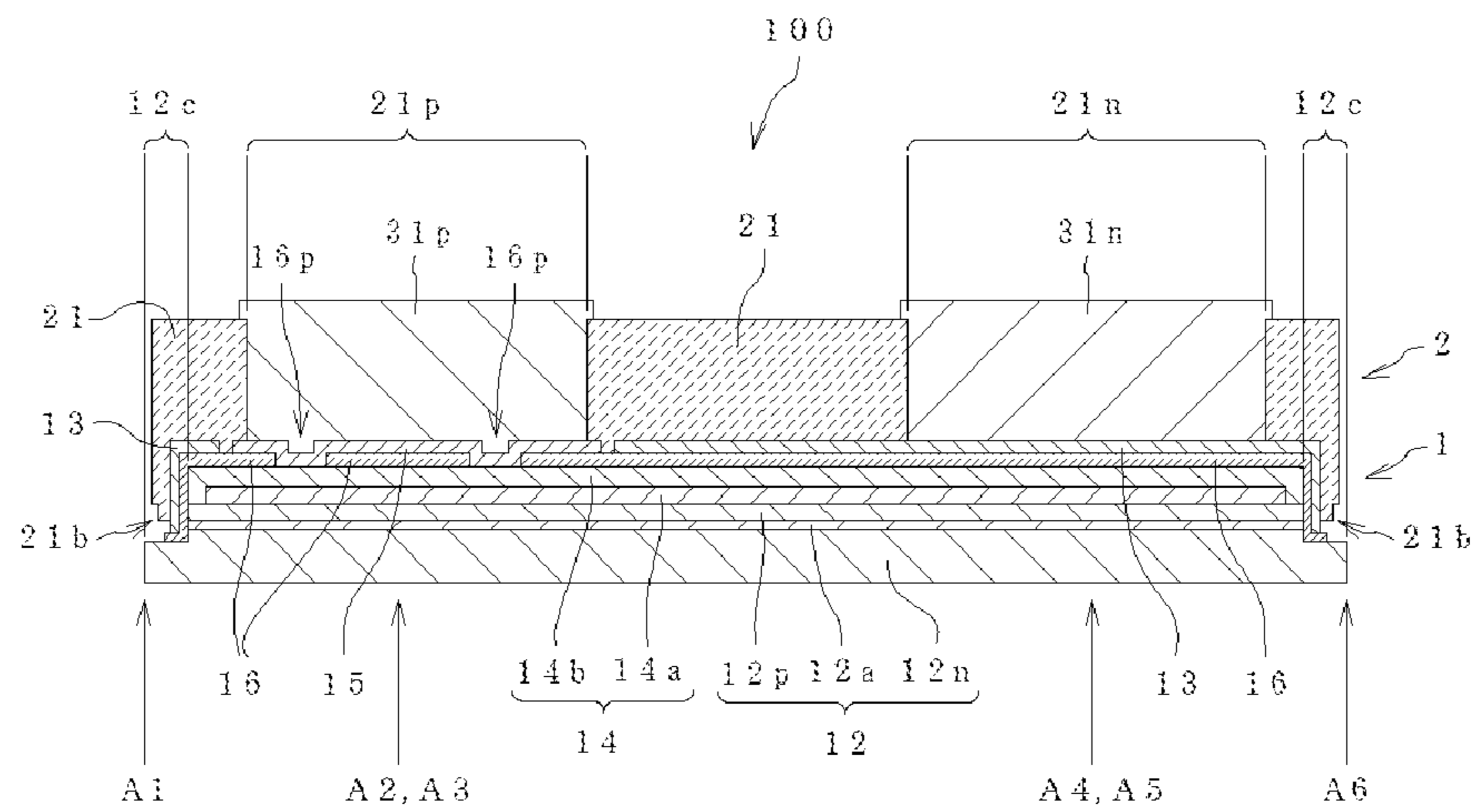


FIG. 3A

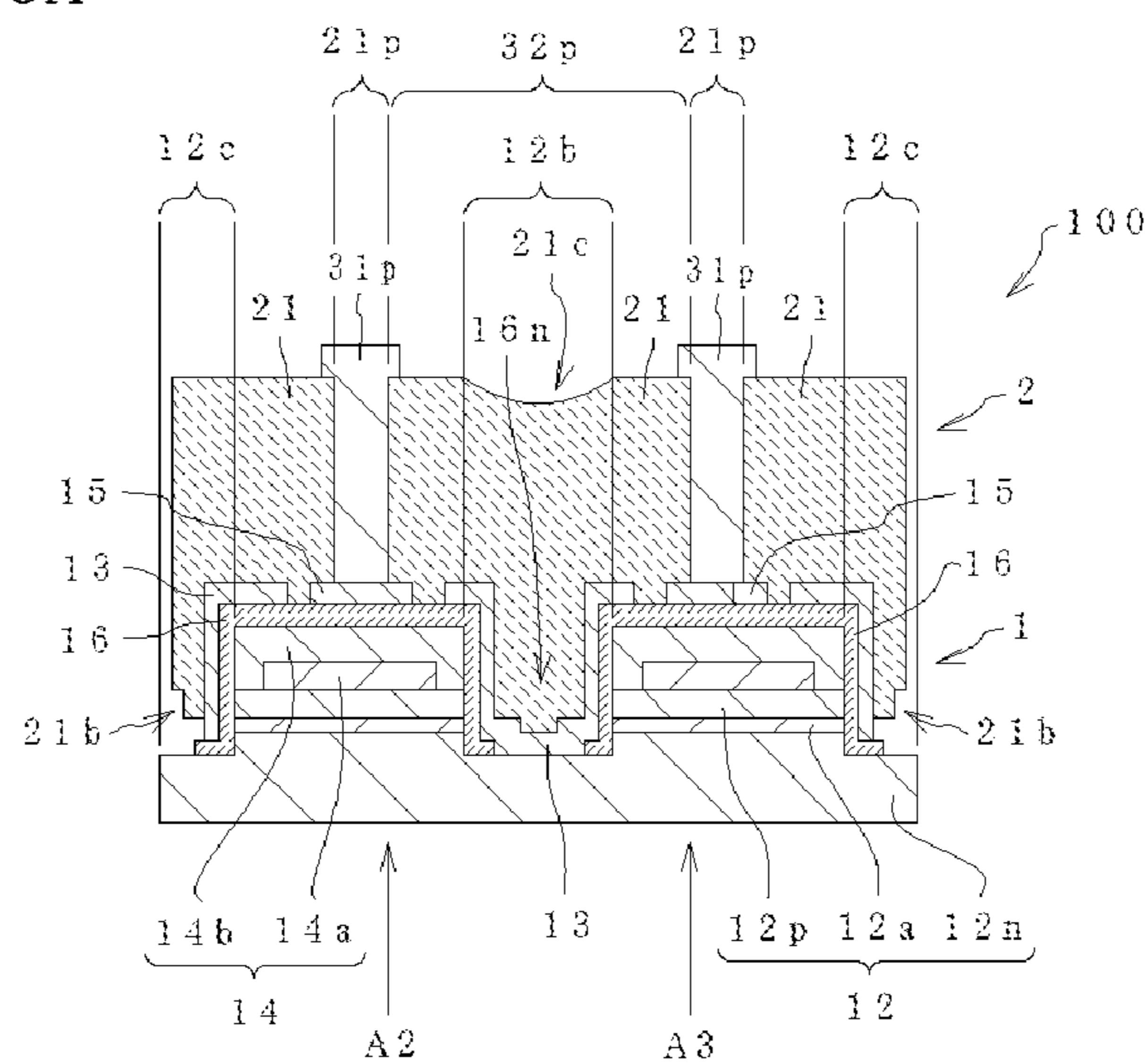


FIG. 3B

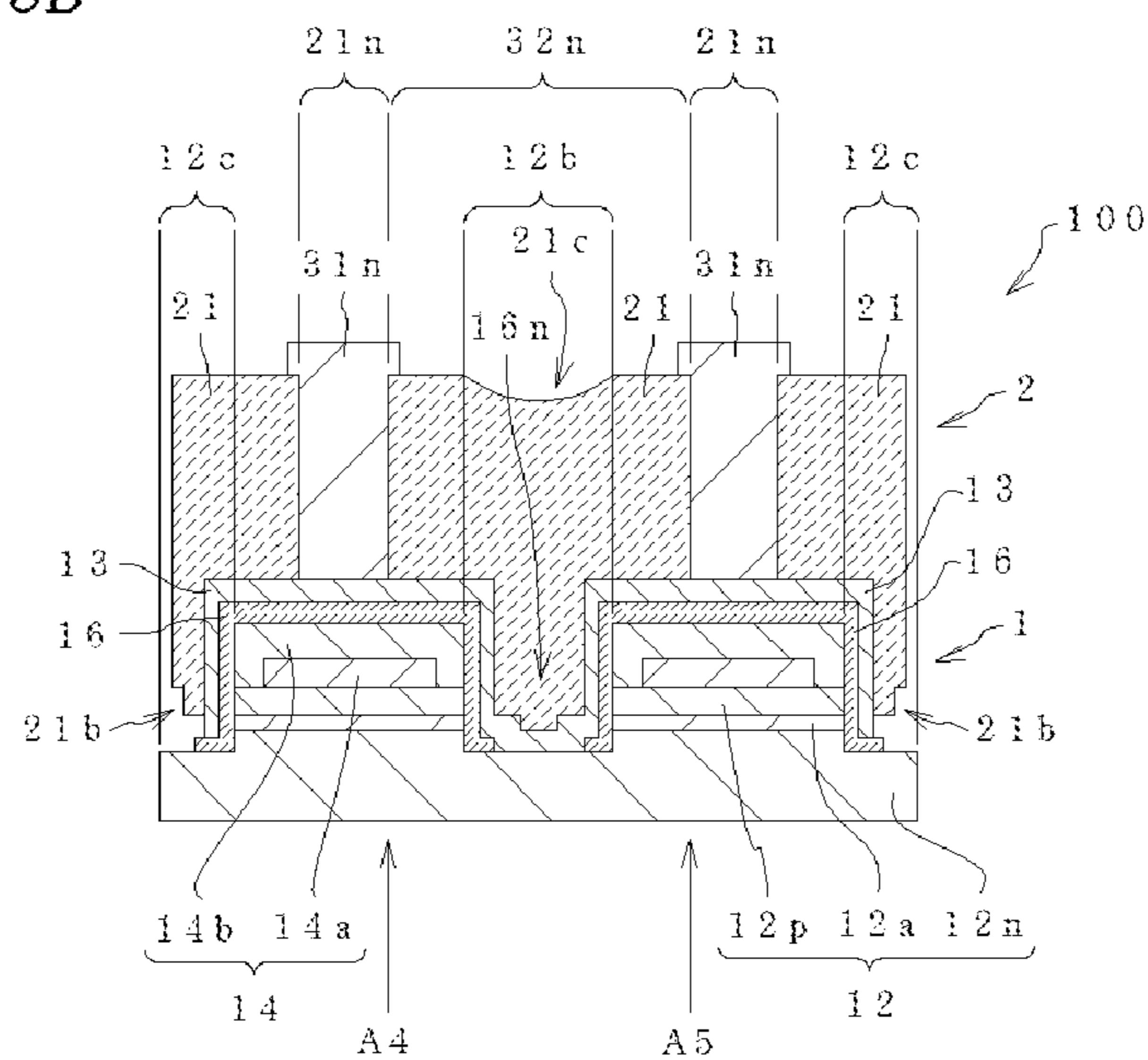


FIG. 4

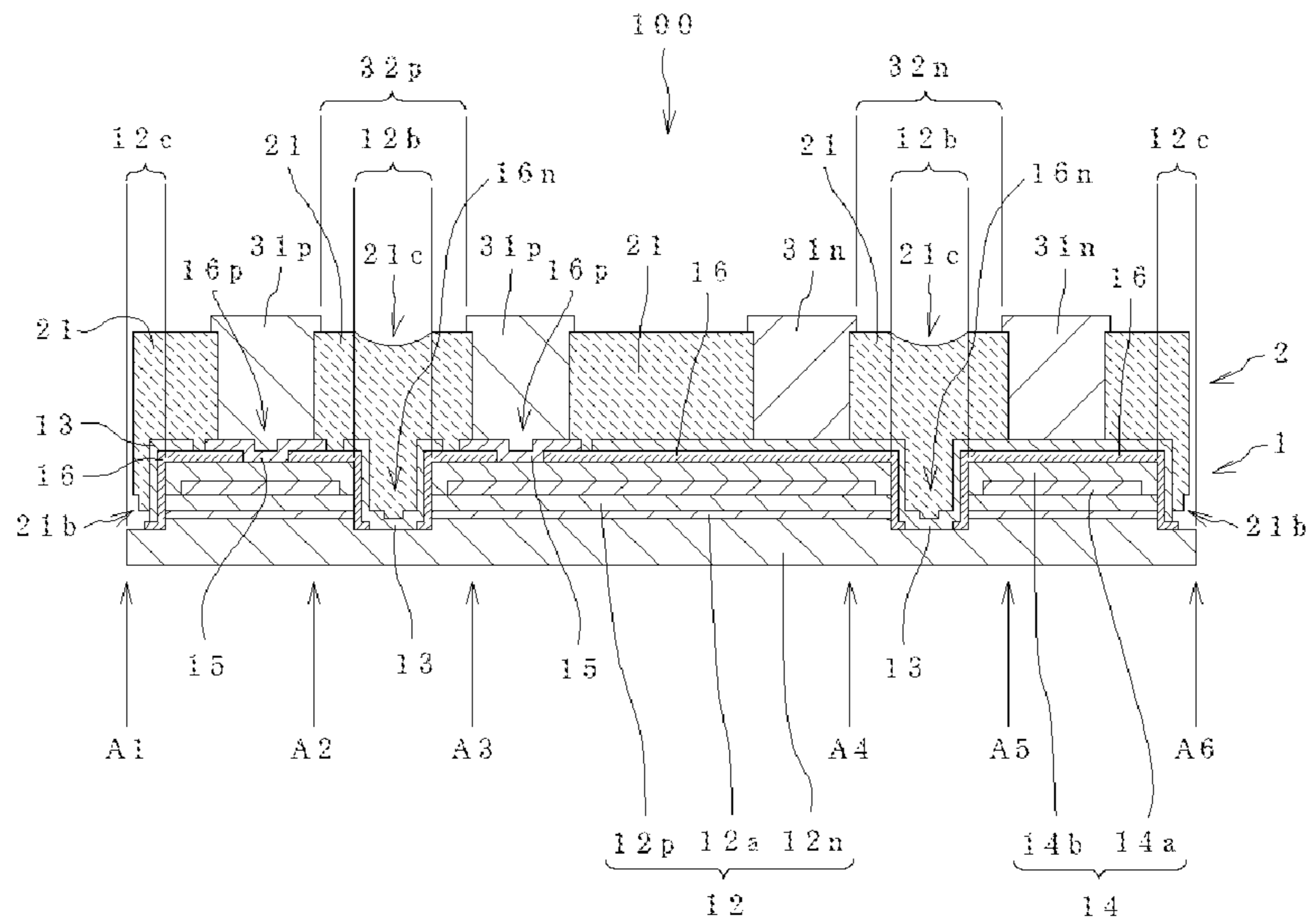


FIG. 5A

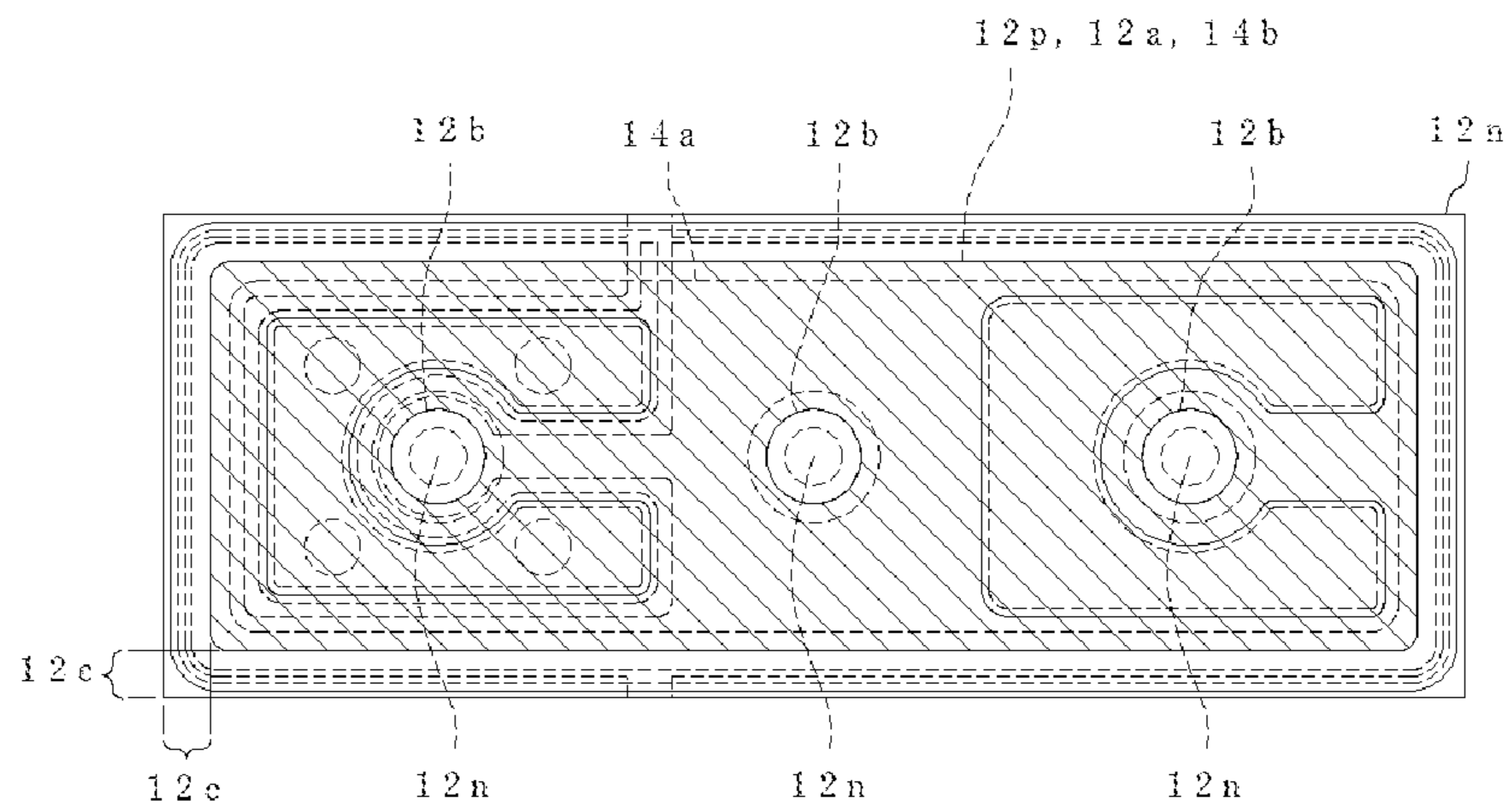


FIG. 5B

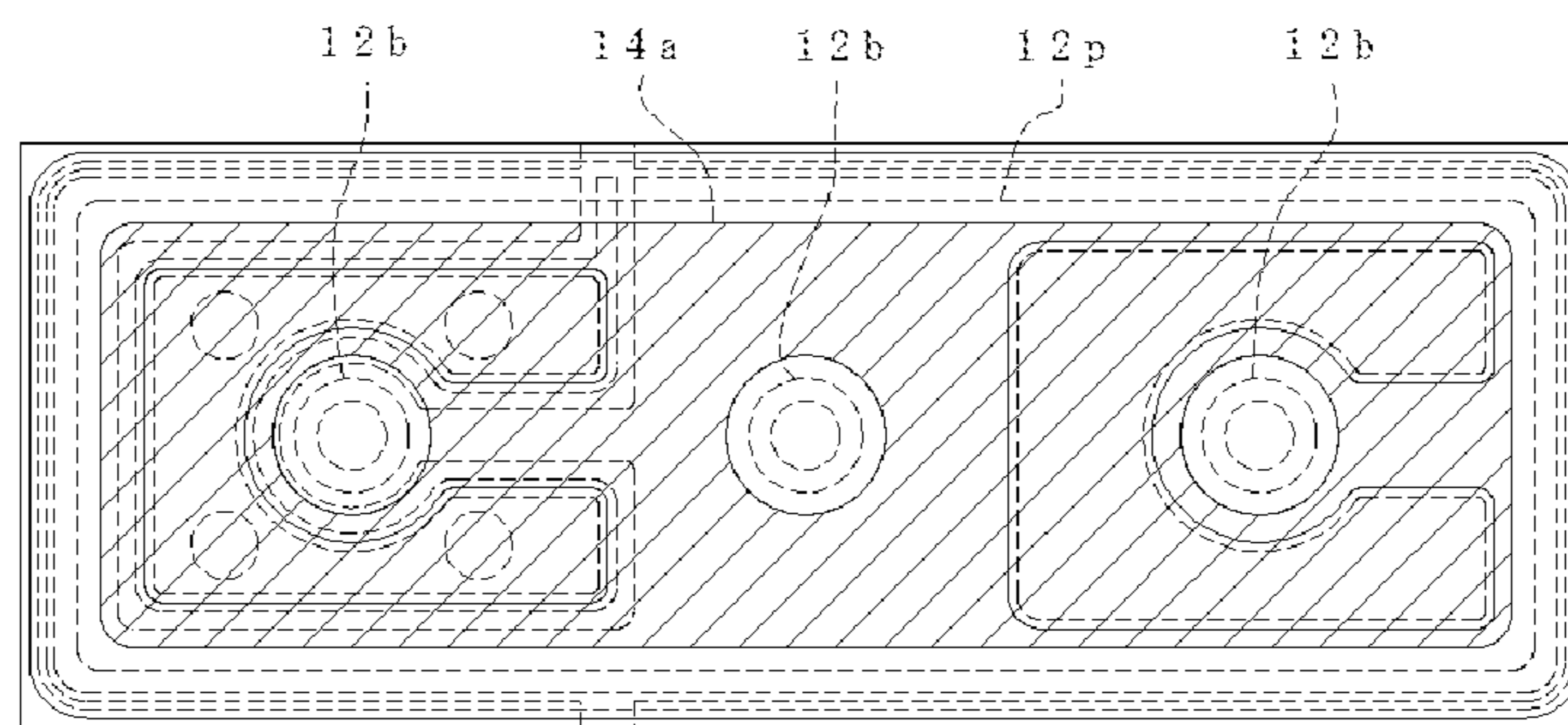


FIG. 6A

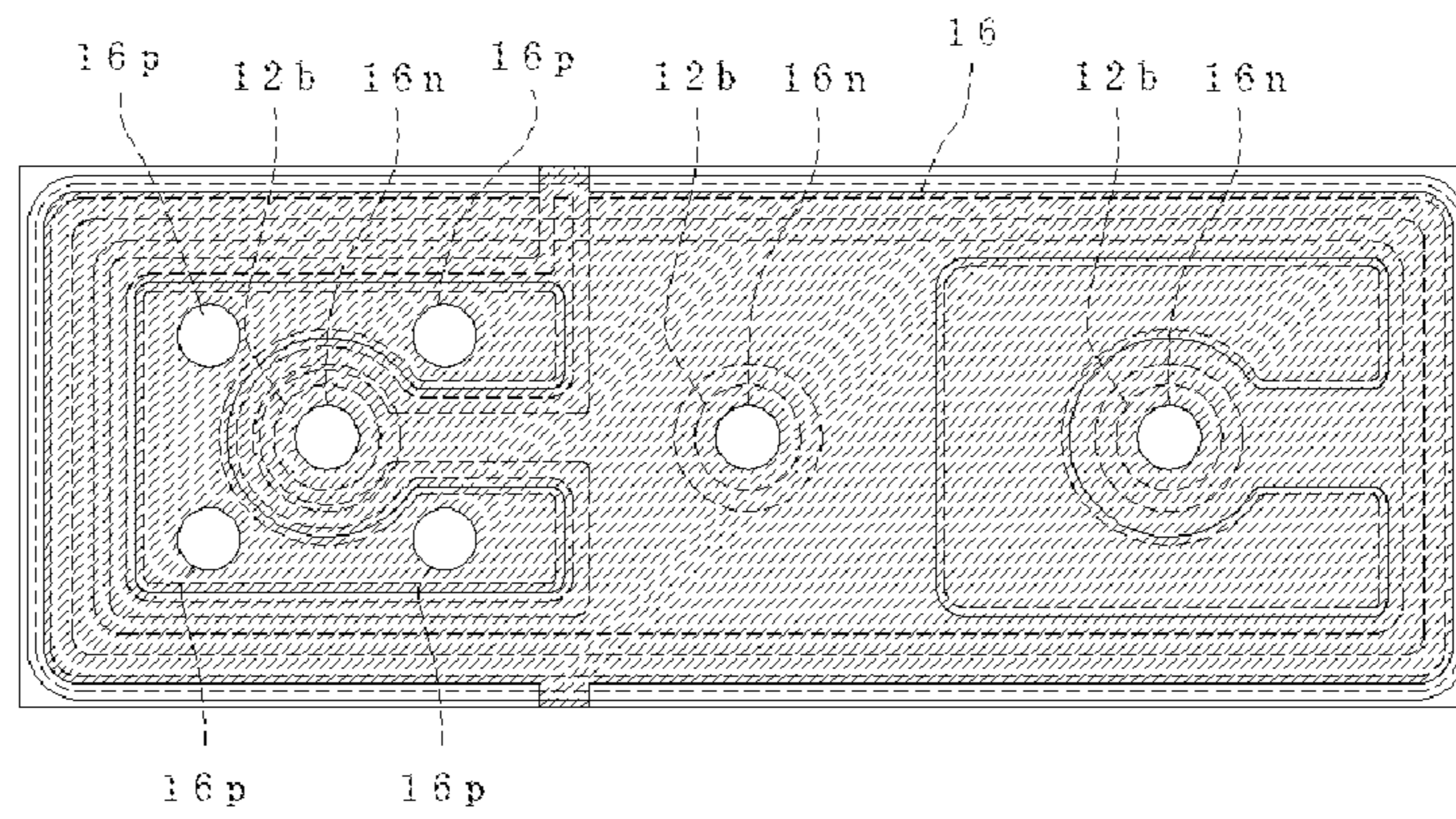


FIG. 6B

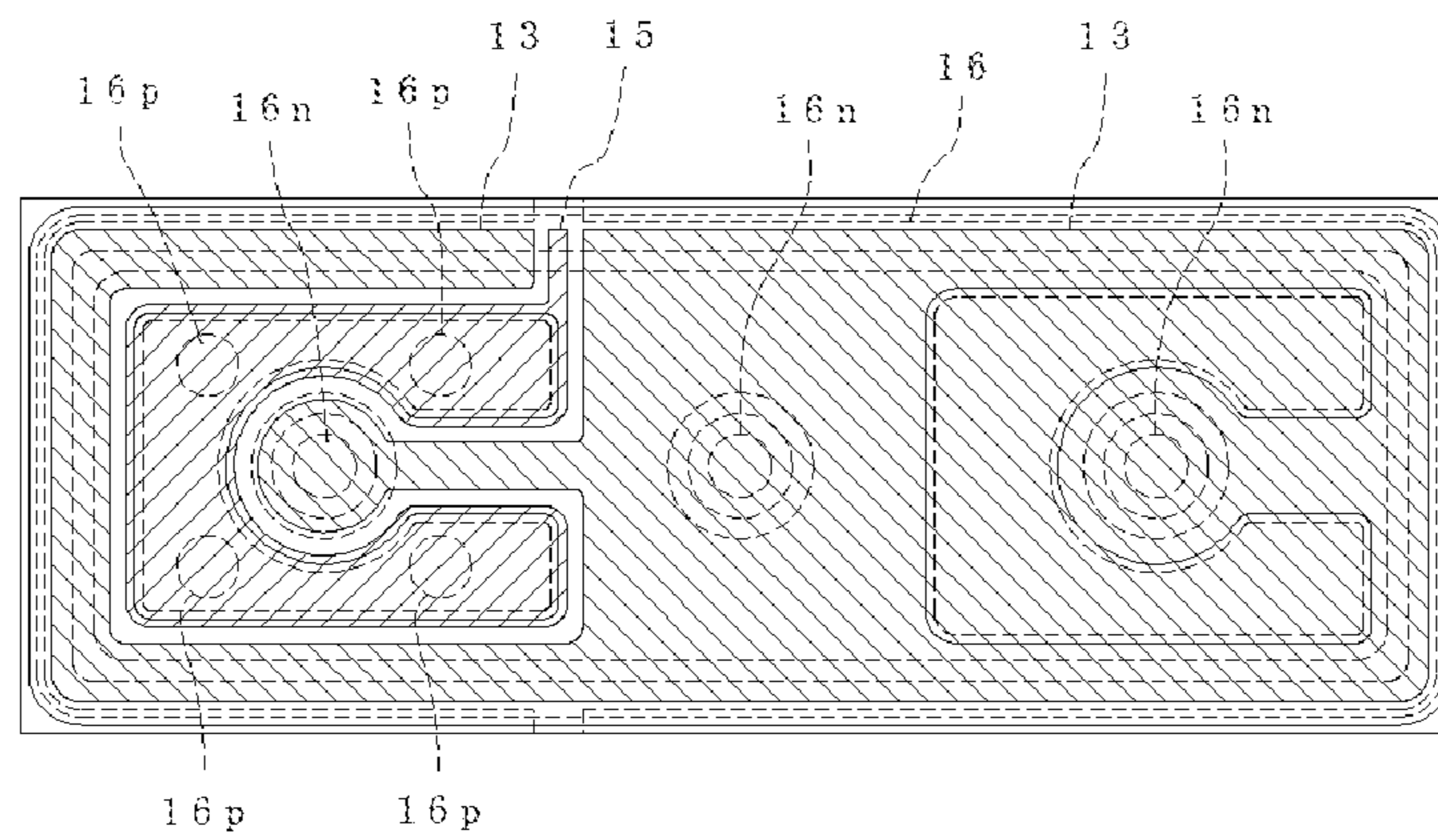




FIG. 7

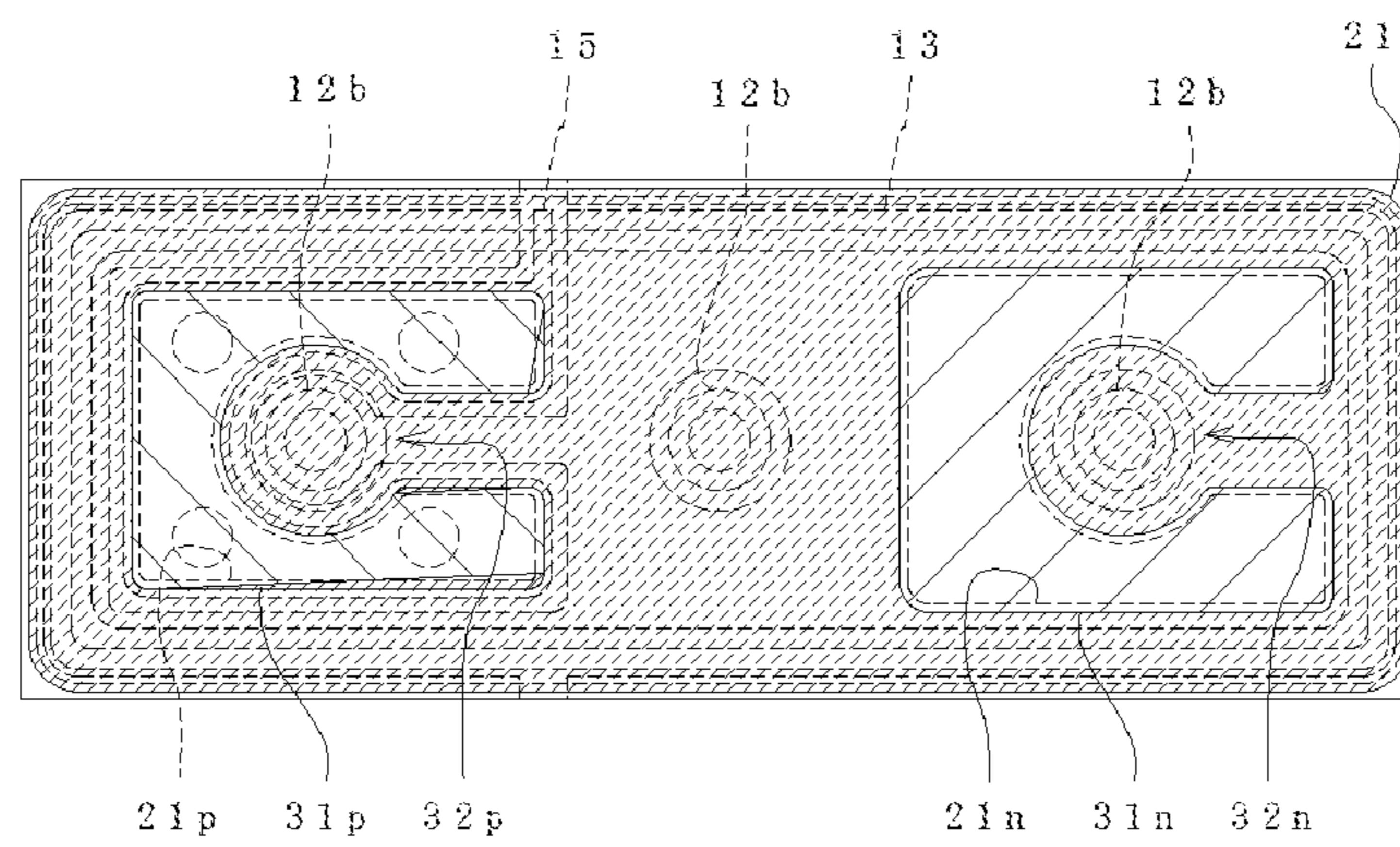


FIG. 8

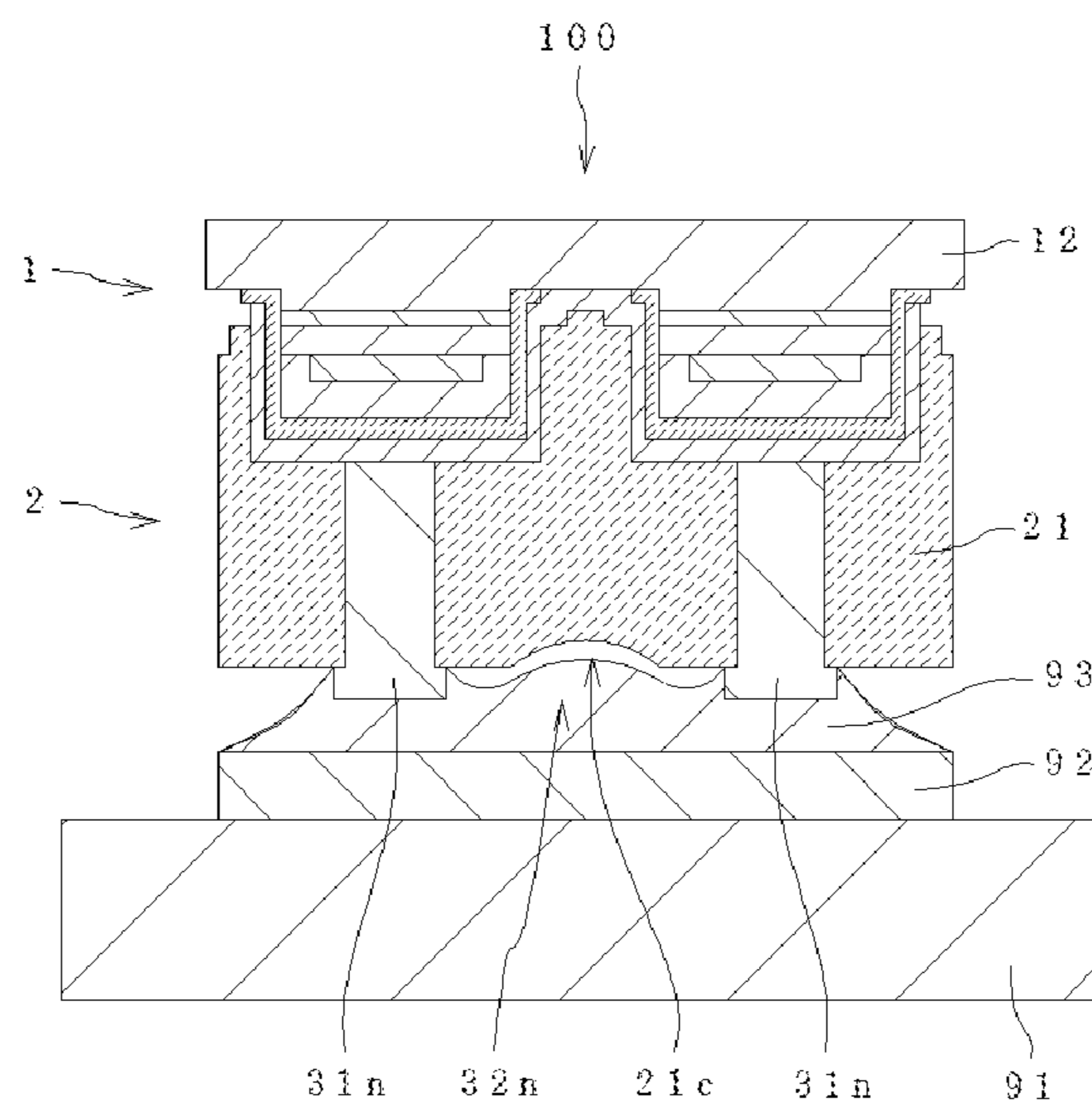


FIG. 9

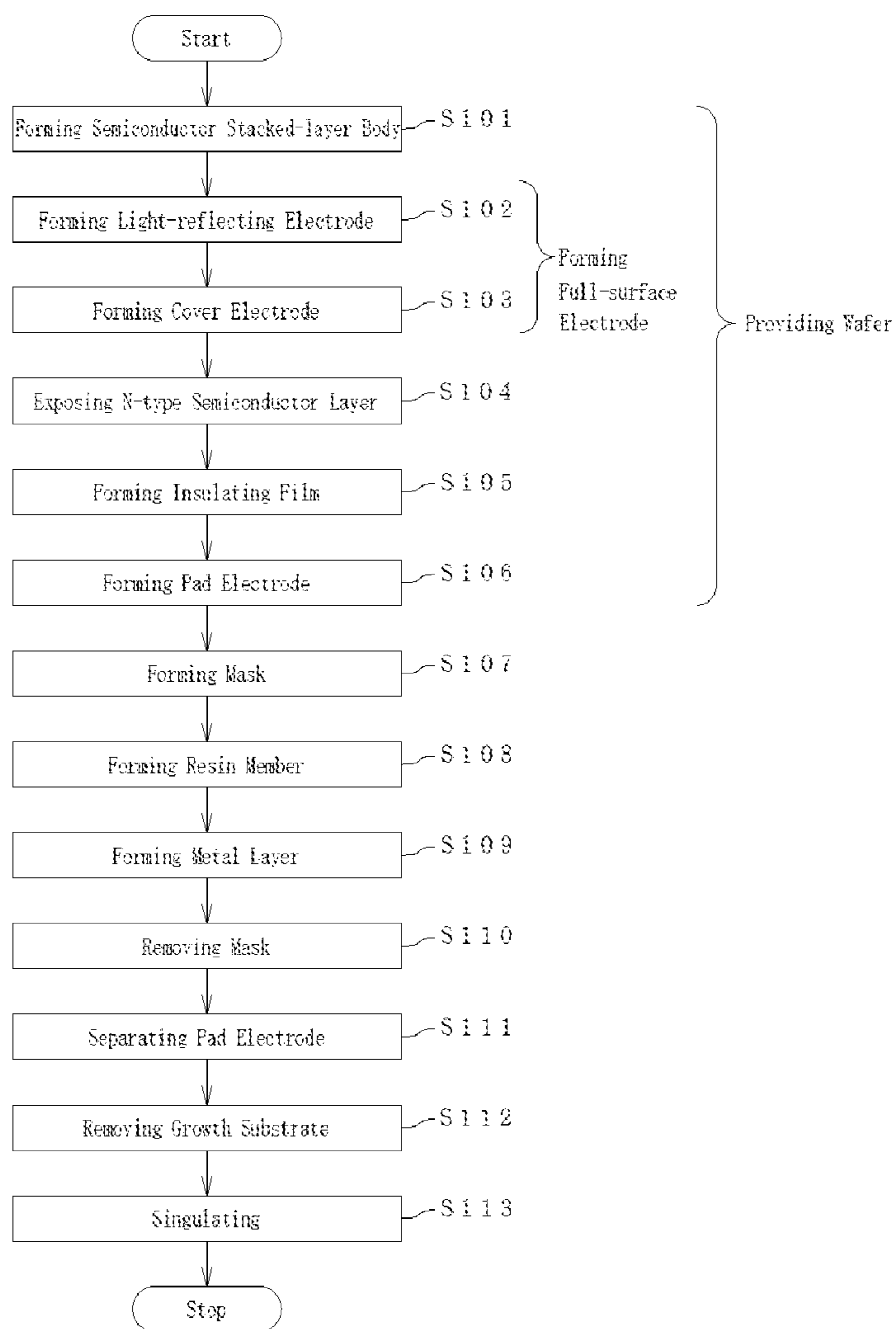


FIG. 10A

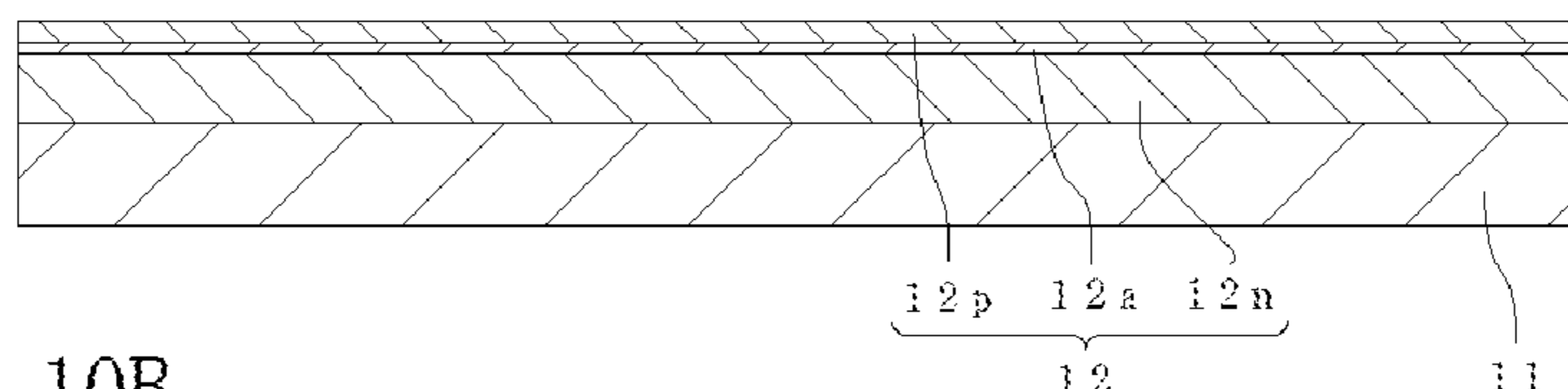


FIG. 10B

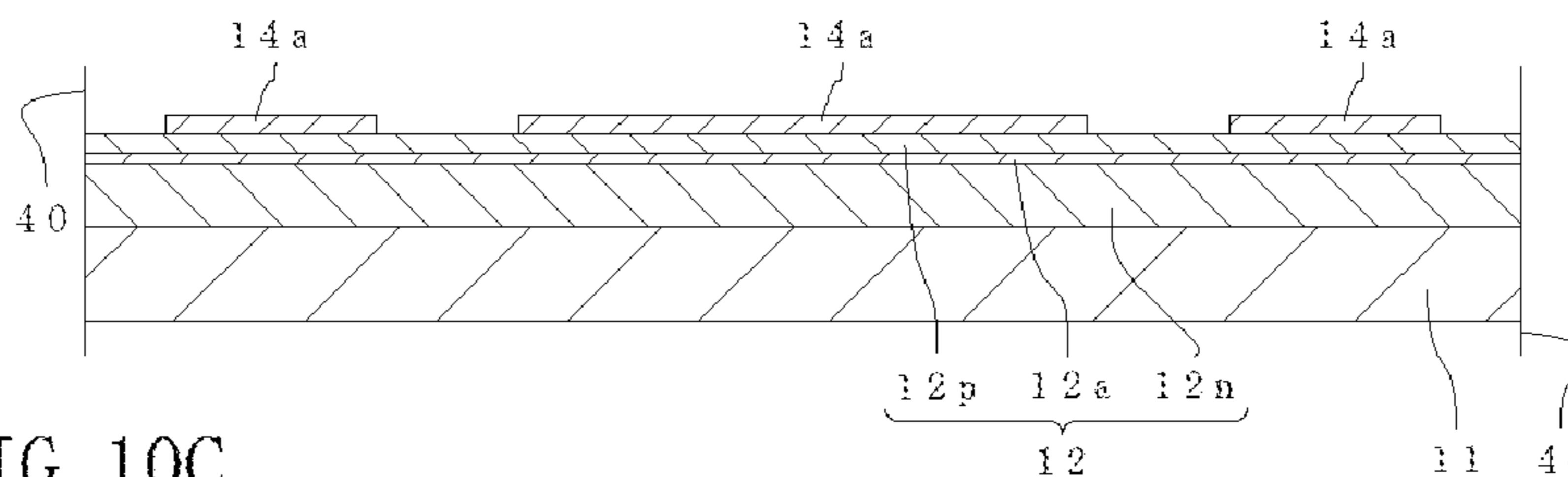


FIG. 10C

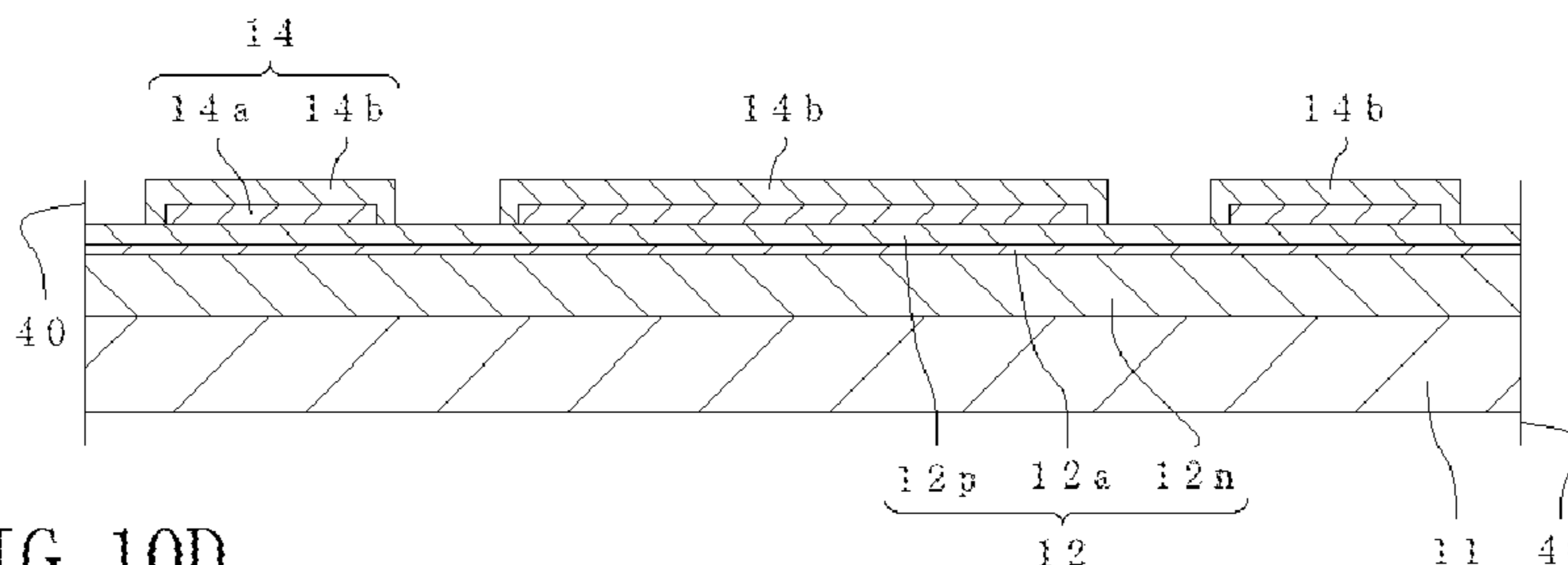


FIG. 10D

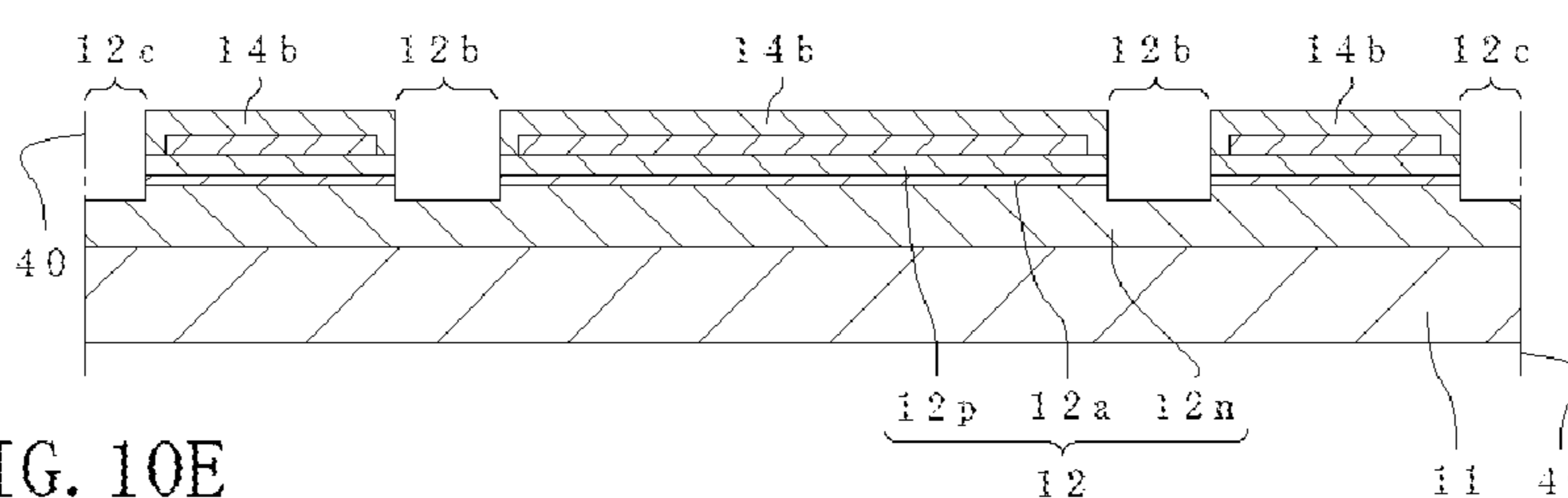


FIG. 10E

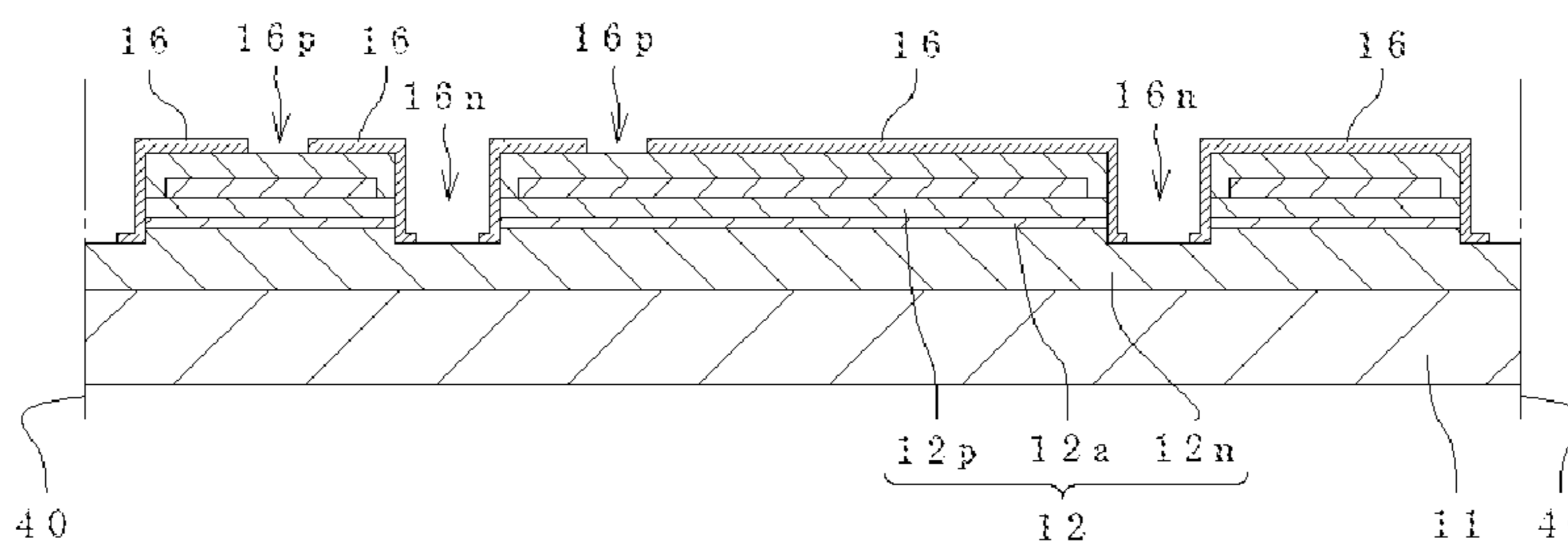


FIG. 11A

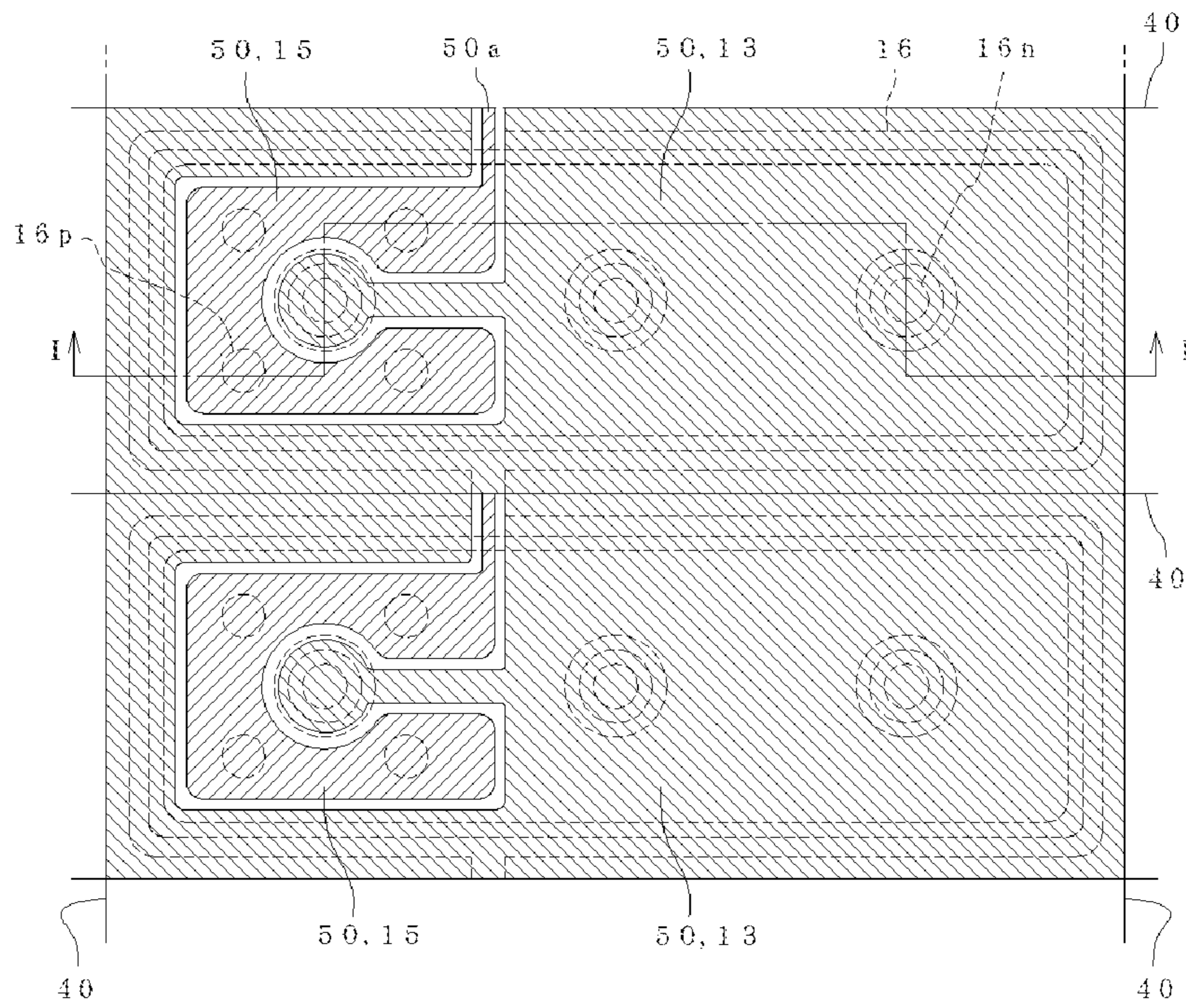


FIG. 11B

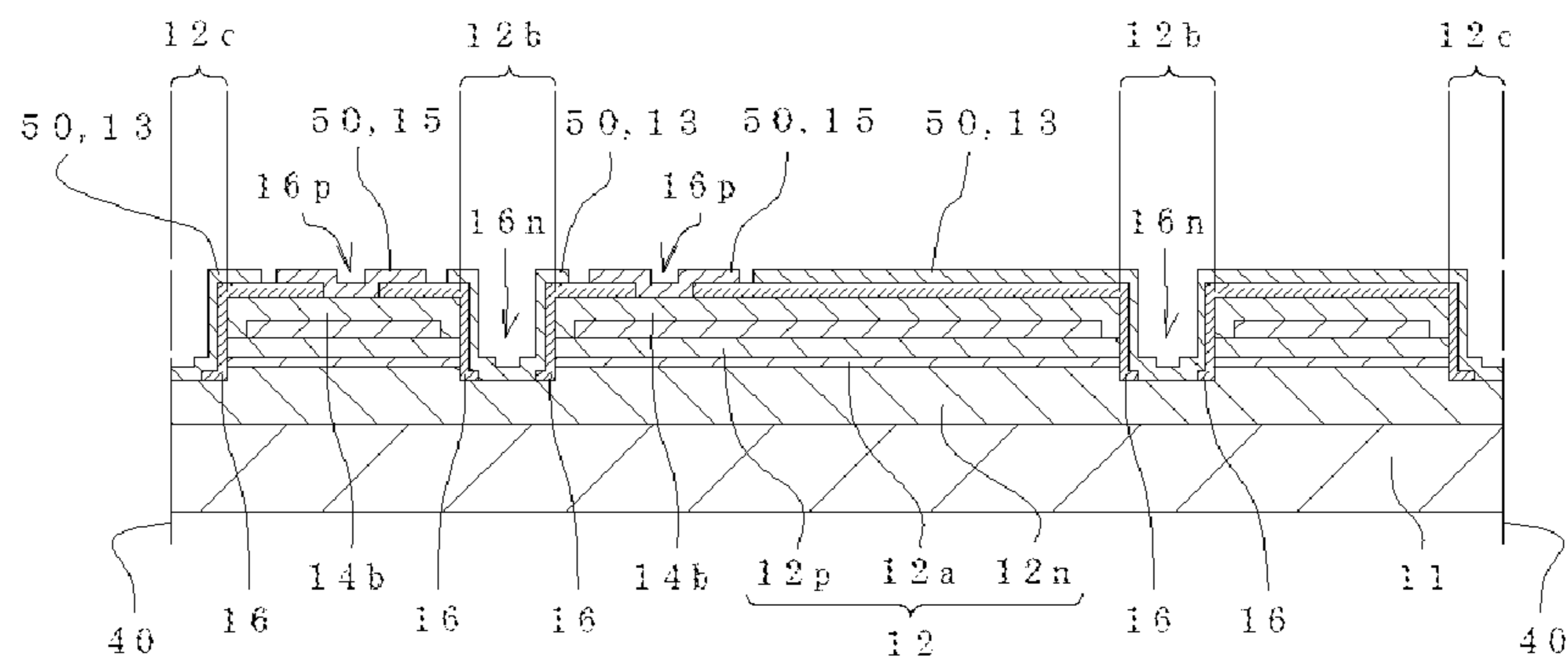


FIG. 12A

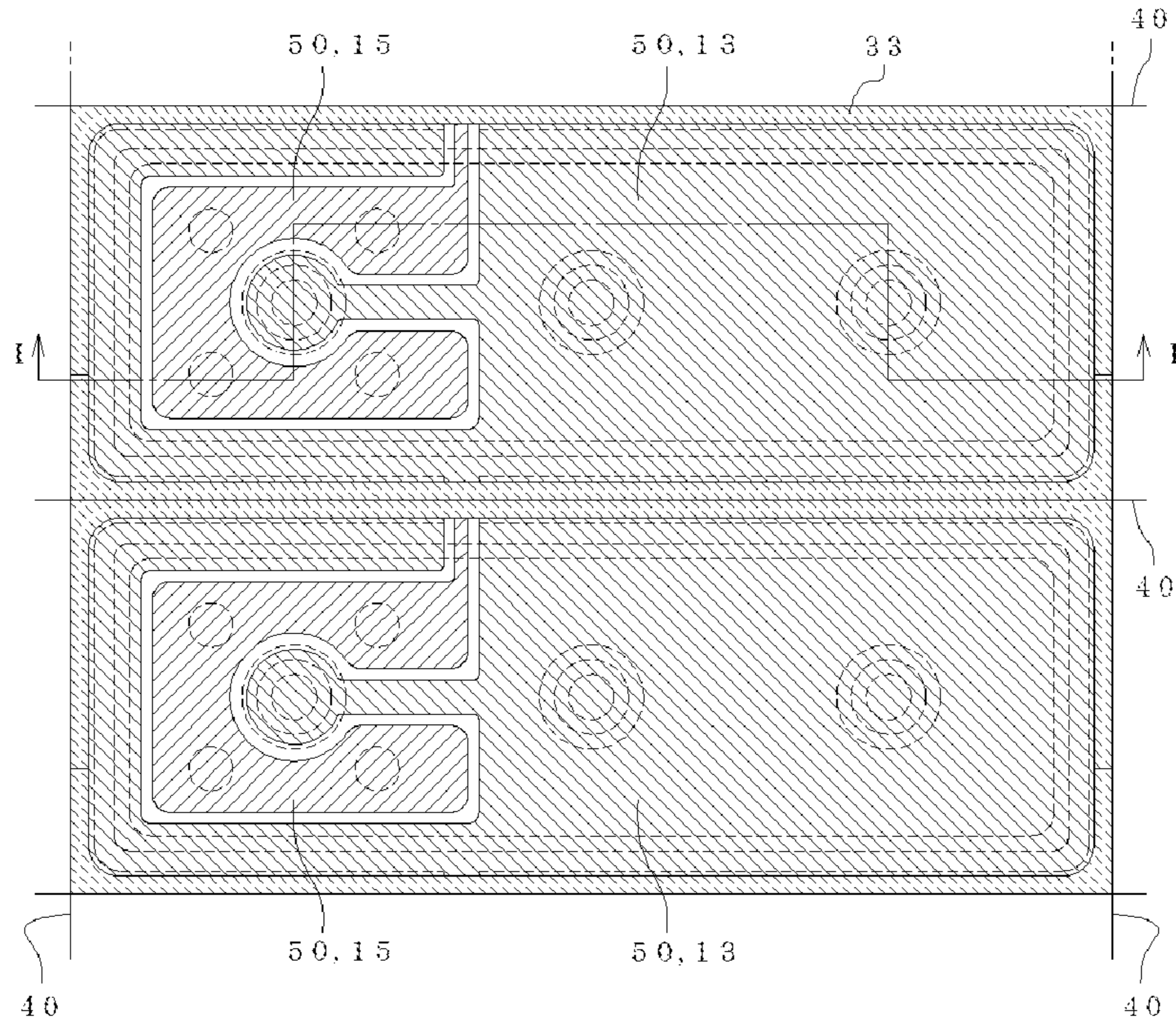


FIG. 12B

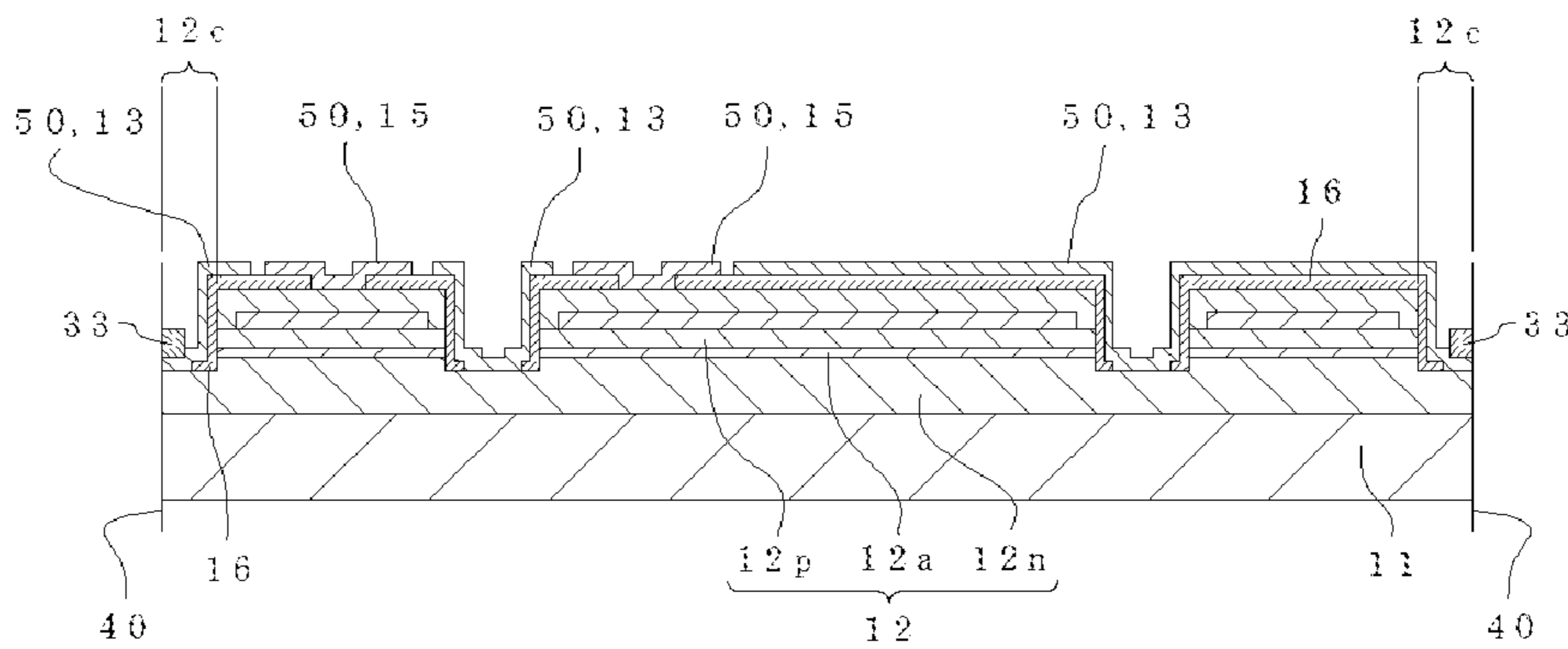


FIG. 13A

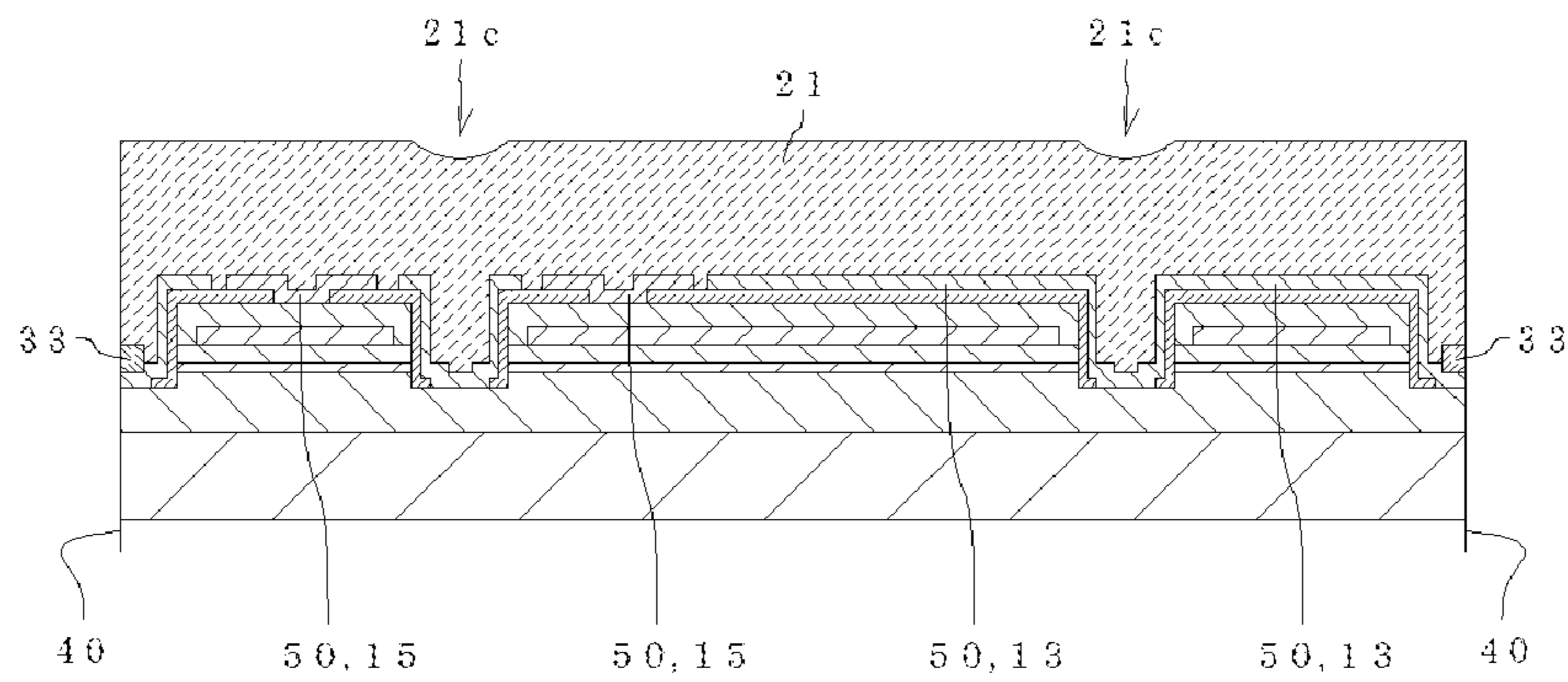


FIG. 13B

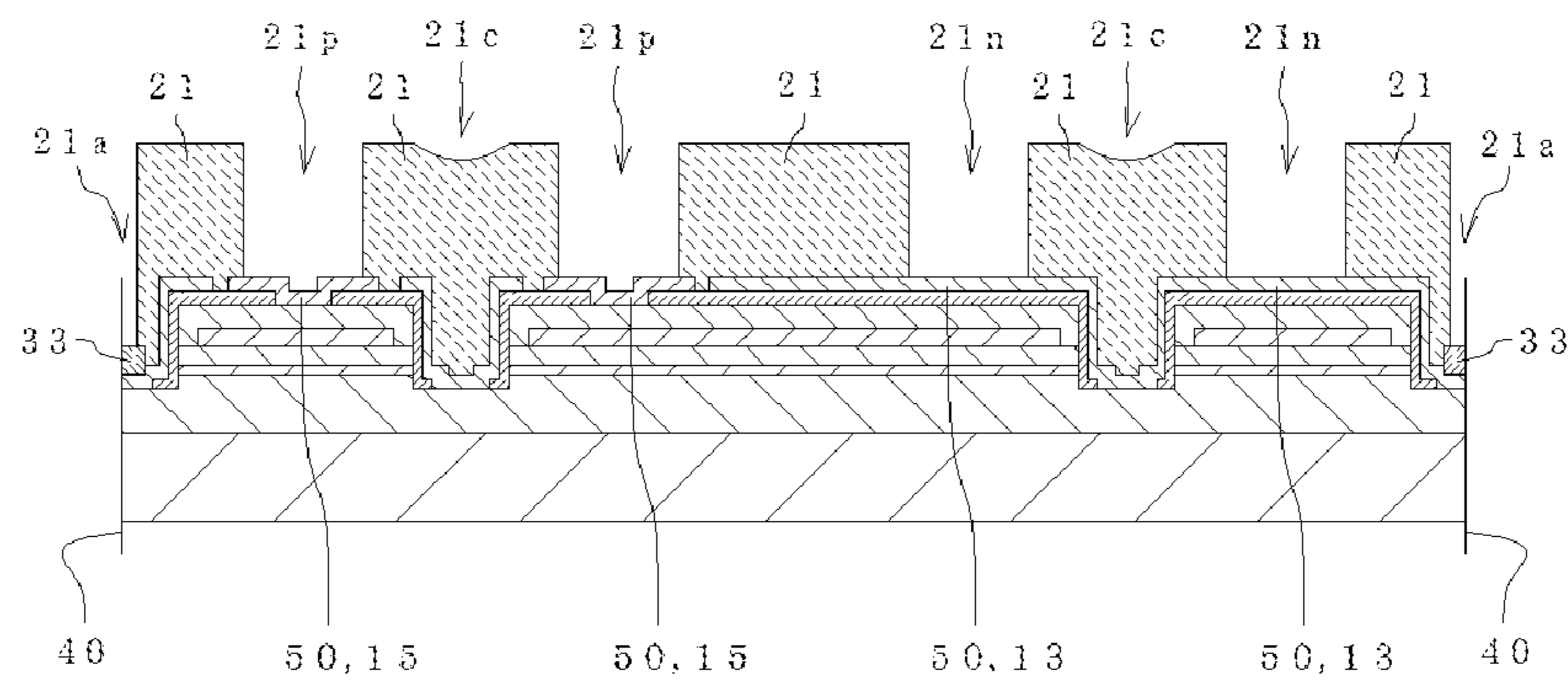


FIG. 14A

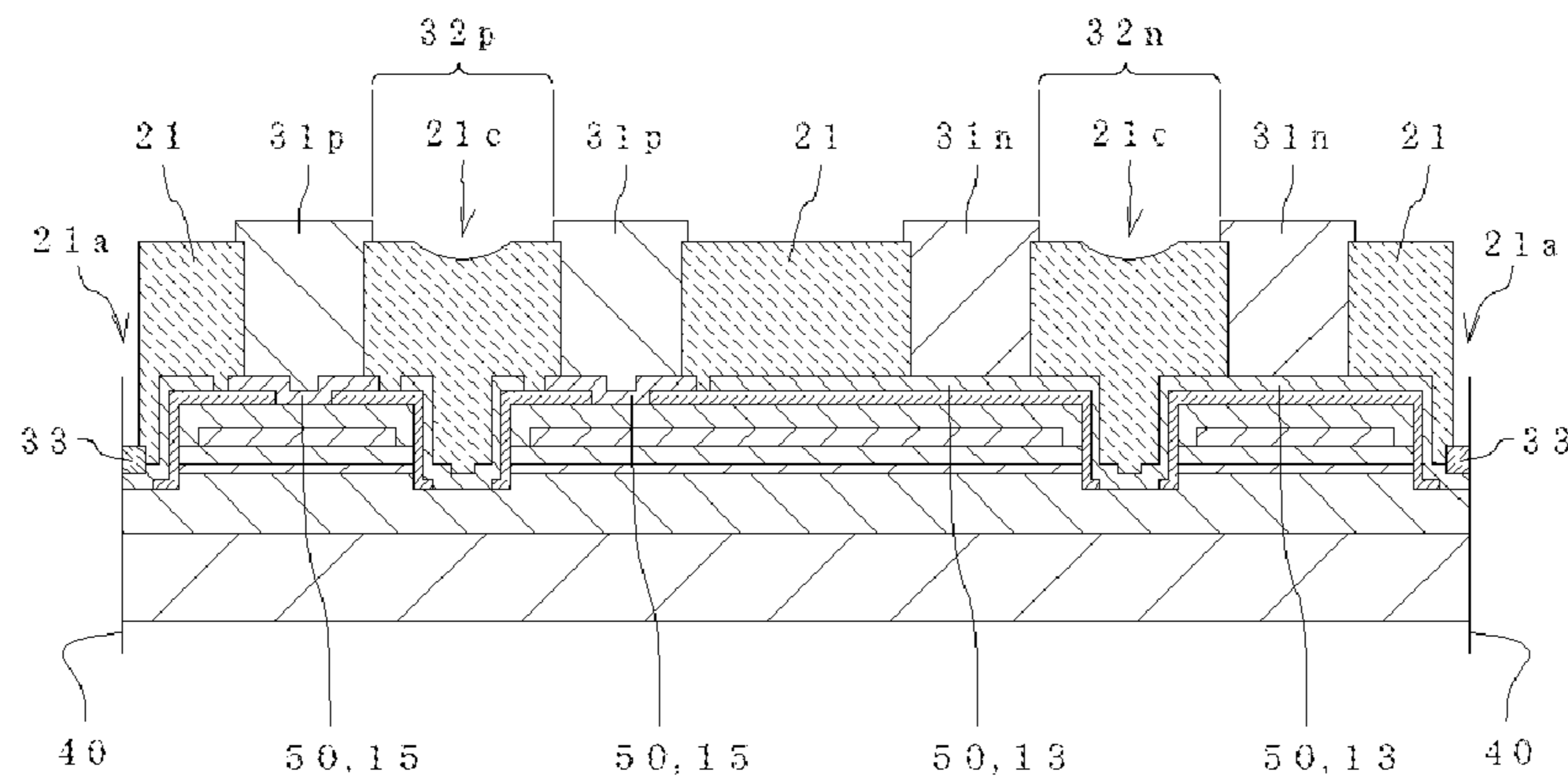


FIG. 14B

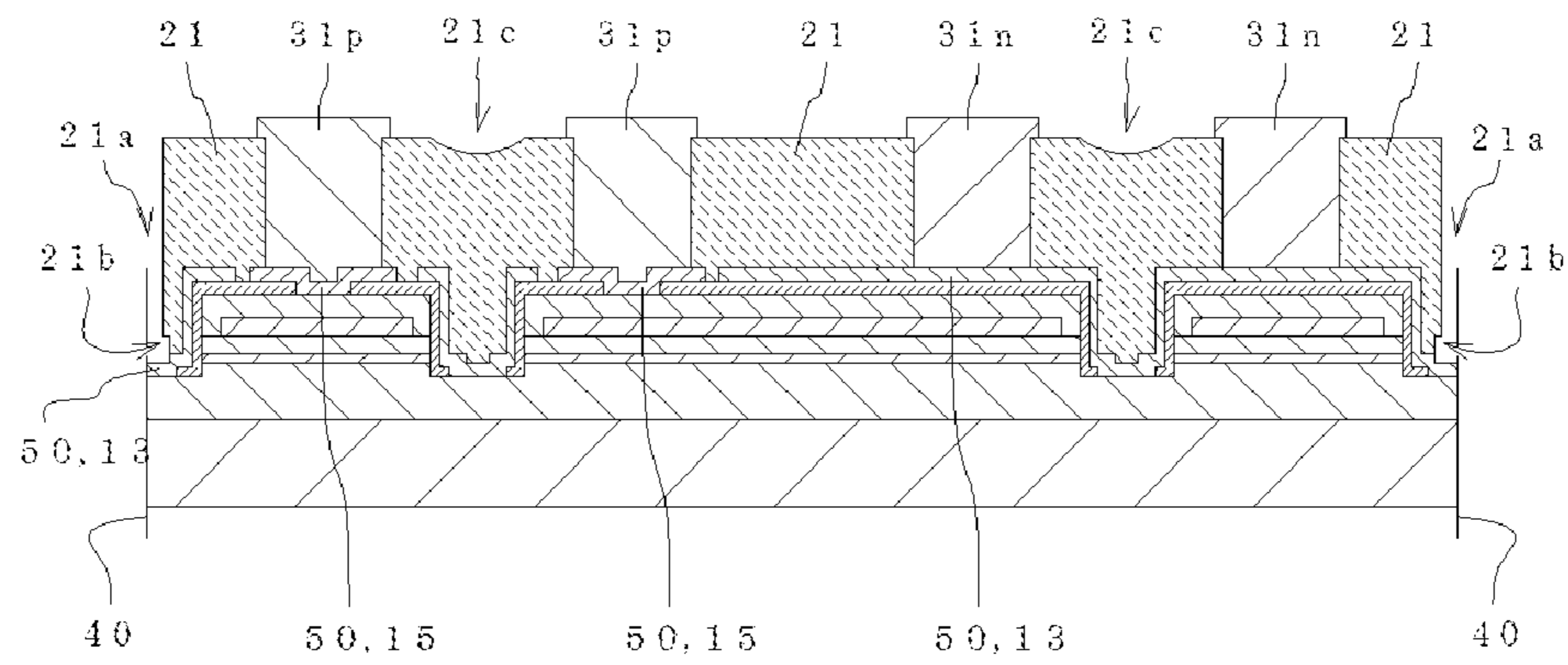




FIG. 15A

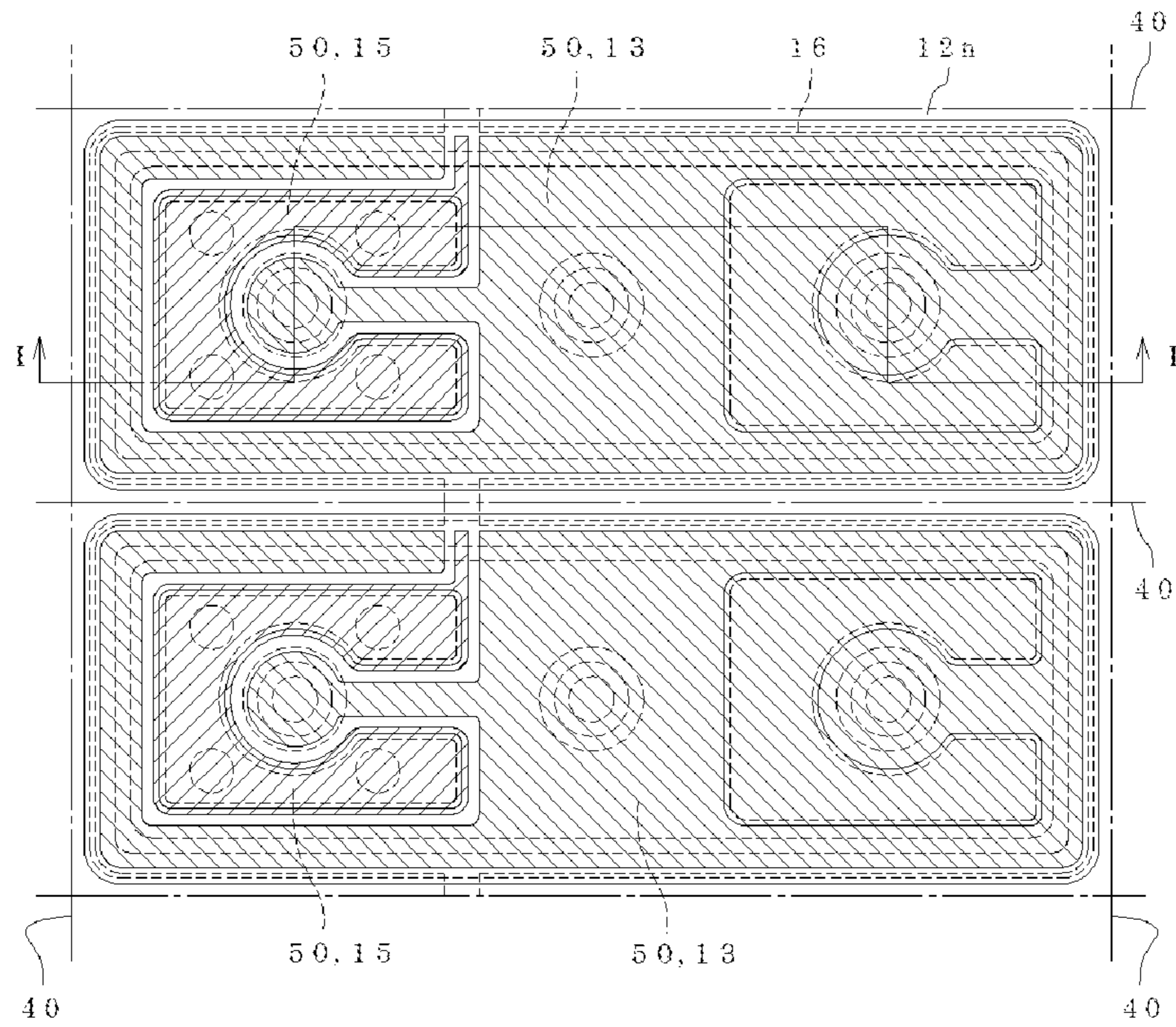


FIG. 15B

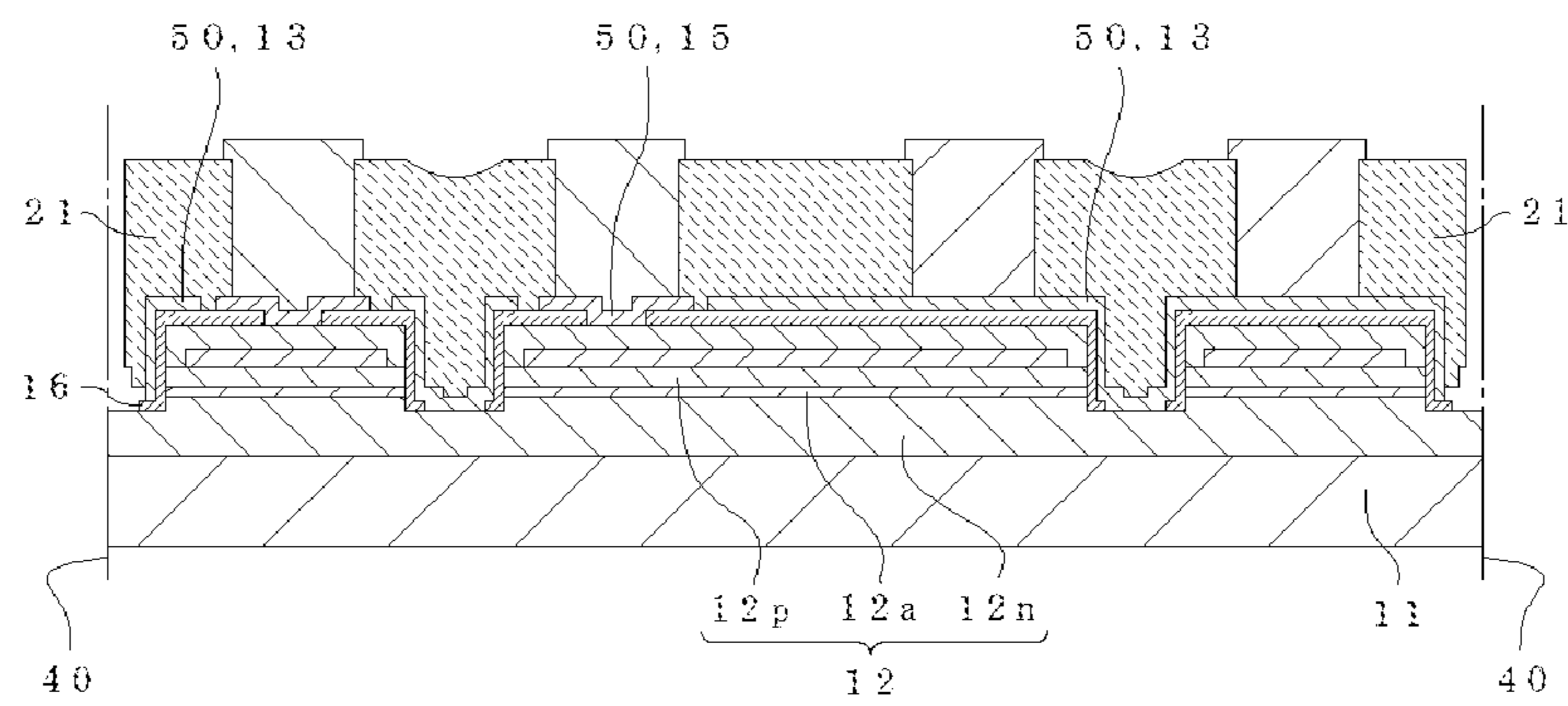


FIG. 16

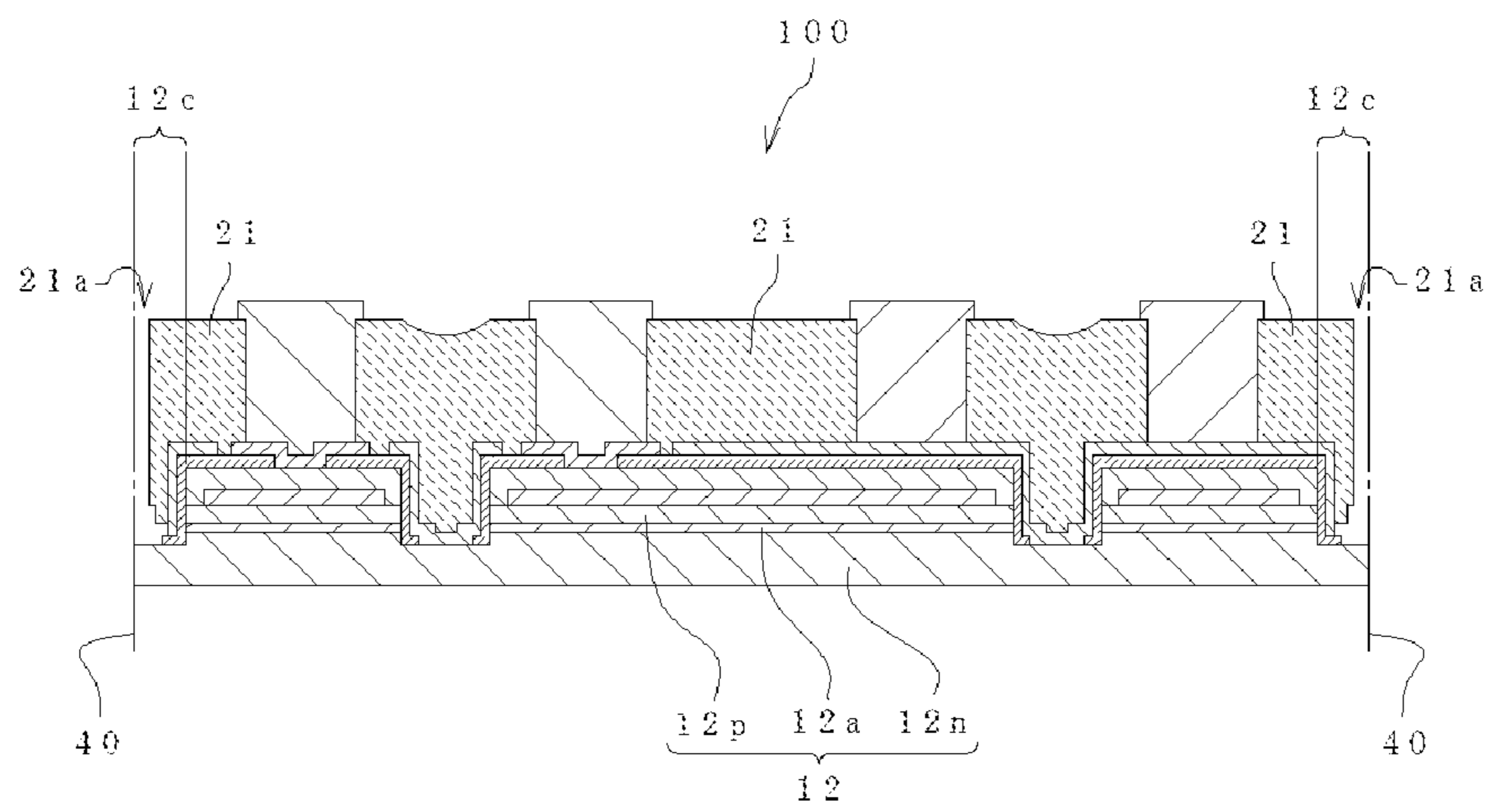


FIG. 17A

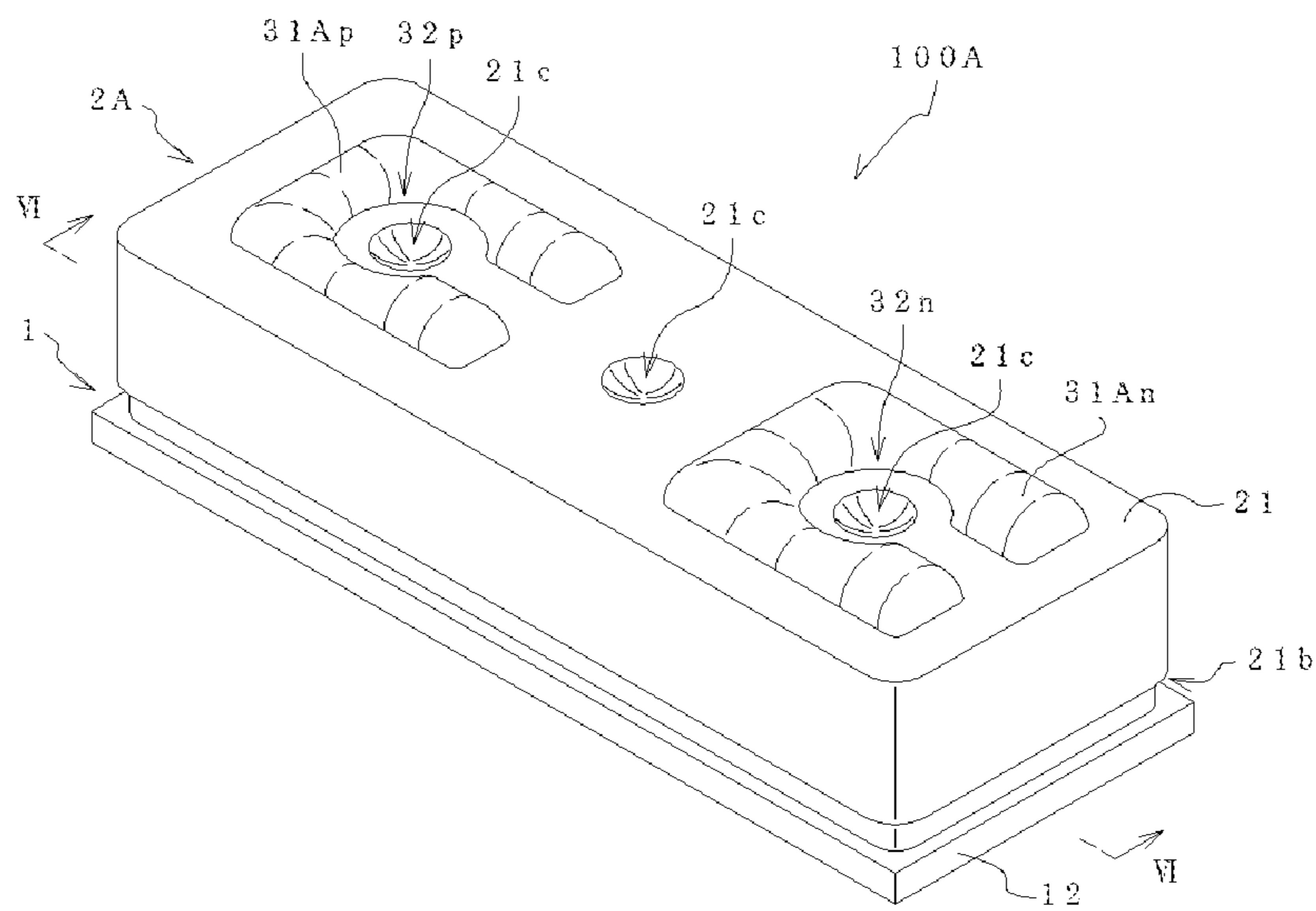
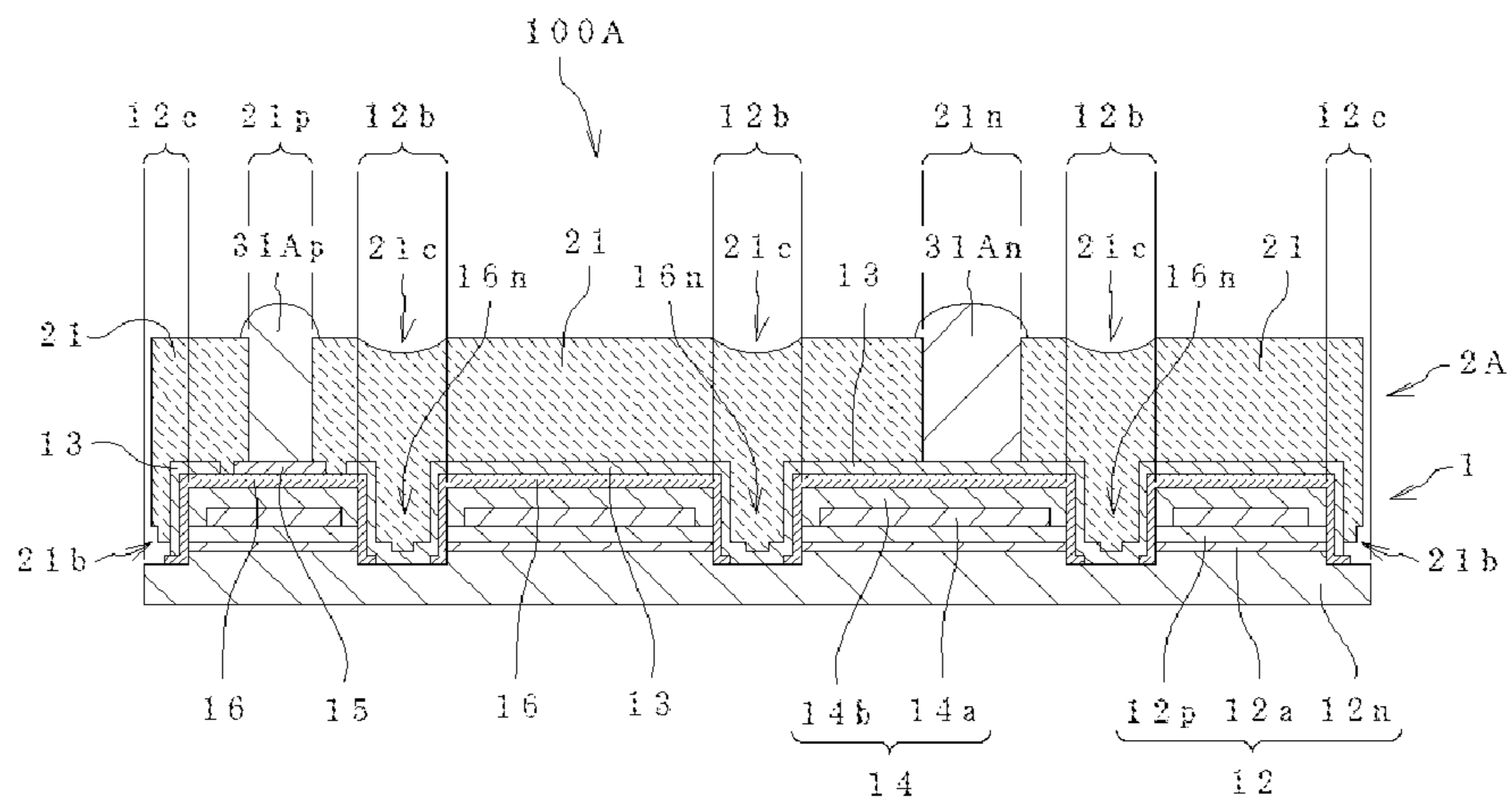


FIG. 17B



# LIGHT EMITTING DEVICE AND METHOD OF MANUFACTURING LIGHT EMITTING DEVICE

## CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 14/821,369, filed on Aug. 7, 2015, which claims priority to Japanese Patent Application No. 2014-163124, filed on Aug. 8, 2014, the entireties of which are hereby incorporated by reference.

## BACKGROUND

### 1. Technical Field

The present disclosure relates to a light emitting device that includes a semiconductor light emitting element and a resin member provided with an internal wiring, and to a method of manufacturing the same.

### 2. Description of the Related Art

Light emitting devices using a semiconductor light emitting element such as a light emitting diode are widely used because of ease of miniaturization and high light emission efficiency. The light emitting elements used in light emitting devices can be roughly divided into two types, namely, a face up type in which a surface of a semiconductor light emitting element for disposing a pad electrode is on the opposite side from the mounting surface, and a face down type in which a surface of a light emitting element for disposing an electrode is a lower surface that faces a mounting substrate.

In the face up type, a semiconductor light emitting element is mounted on leads or the like, and the semiconductor light emitting element and the leads are connected via bonding wires or the like. Accordingly, in a plan view of a semiconductor light emitting element disposed on a mounting substrate—that is, seen from a perpendicular direction relative to the mounting surface of the mounting substrate—portions of the wires are needed to be outer side of the semiconductor light emitting element, which imposes a limitation in miniaturization of the light emitting element.

On the other hand, in the face down type (or flip chip type), a pad electrode disposed on a surface of a semiconductor light emitting element and a wiring disposed on a mounting substrate can be electrically connected via a connector such as a bump or a metal pillar, which are positioned within the outer peripheral line of the semiconductor light emitting element in a plan view seen from a direction perpendicular to the mounting surface of the mounting substrate. This configuration allows forming of a CSP (Chip Size Package or Chip Scale Package) in which the size of a light emitting device (particularly the size in a plan view seen from a direction perpendicular to the mounting surface of the mounting substrate) is reduced almost to the size of the chip of a semiconductor light emitting element.

In recent years, in order to achieve further miniaturization, or in order to further improve the light emission efficiency, a face down type light emitting device has been proposed, in which a growth substrate (a light-transmissive substrate) such as sapphire has been removed, or the thickness of the growth substrate has been reduced.

The growth substrate is a substrate for growing thereon an n-type semiconductor layer and a p-type semiconductor layer that are components of a semiconductor light emitting element. The growth substrate also exhibits the effect of

improving the mechanical strength of the light emitting device by supporting a semiconductor light emitting element that is small in thickness and low in strength. Accordingly, in a light emitting device in which the growth substrate is removed or the thickness of the growth substrate is reduced after formation of a semiconductor light emitting element, for example as disclosed in JP 2011-249426 A, a resin layer is disposed on an electrode side (the side facing the mounting substrate) for supporting a bare chip (i.e., a semiconductor light emitting element), and internal wirings made of metal pillars or other wirings are formed so as to penetrate through the resin layer, and the electrode and an external terminal are electrically connected to each other. With such a resin layer that includes an internal wiring, sufficient mechanical strength can be reliably obtained.

In the case where such a light emitting device that has a resin layer disposed on the electrode side is mounted on a mounting substrate by using an electrically conductive adhesive member, for example using a solder and a reflowing method, melted solder may be squeezed out from between the electrode for external connection of the light emitting device and the wiring pattern of the mounting substrate. In particular, when the solder is excessively supplied, the solder squeezed out from between the electrode for external connection of the light emitting device and the wiring pattern of the mounting substrate may rise along a side surface of the resin layer. The solder that rises up the side surface of the resin layer may cause bonding defects between the light emitting device and the mounting substrate, or may contaminate the light extraction surface resulting in a reduction in the light extraction efficiency.

## SUMMARY

Accordingly, an object of certain embodiments of the present invention is to provide a light emitting device with which the amount of adhesive (such as melted solder) that is squeezed out during mounting is reduced, and highly reliable mounting can be achieved, and a method of manufacturing the same.

A light emitting device according to an embodiment of the present invention includes a semiconductor light emitting element that includes a semiconductor stacked-layer body and an electrode disposed on one surface of the semiconductor stacked-layer body, a resin member disposed on the one surface side of the semiconductor stacked-layer body, and a metal layer disposed in the resin member and electrically connected to the electrode. A recess is defined in an upper surface of the resin member, and the metal layer is projected from the upper surface of the resin member, and is disposed to surround at least a portion of the recess.

A method of manufacturing a light emitting device according to an embodiment of the present invention is a method of manufacturing a light emitting device that includes a semiconductor light emitting element which includes a semiconductor stacked-layer body and an electrode disposed on one surface of the semiconductor stacked-layer body. The method includes a step of providing a wafer having a plurality of light emitting elements arranged in arrays, each light emitting element provided with the semiconductor stacked-layer body having an n-type semiconductor layer and a p-type semiconductor layer being stacked, a step difference formed by removing a portion of the semiconductor stacked-layer body from a predetermined region of an upper surface of the p-type semiconductor layer in a thickness direction to expose the n-type semiconductor layer, a step of forming a resin member comprising defining

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a recess by applying a liquid resin material to a one surface side of the semiconductor stacked-layer body to form a recess corresponding to a shape of the step difference in a surface of the applied resin material, and defining an opening in a portion of a surface region of the applied resin material above the electrode so that the opening at least partially surround the recess in a plan view, a step of forming a metal layer by filling the opening with a metal material so as to project further than an upper surface of the resin member, and singulating the wafer into a plurality of the semiconductor light emitting elements by cutting the wafer along boundary lines among the semiconductor light emitting elements.

With the light emitting device according to certain embodiments of the present invention, at the time of mounting, excessive adhesive can be held in the recess of the resin member and the space formed by the upper portion of the metal layer that is projecting from the resin member so as to at least partially surround the recess portion. Therefore, the amount of solder squeezed out from the arrangement region of the metal layer that is the mounting surface can be reduced. As a result, highly reliable mounting can be realized. Further, with the method of manufacturing a light emitting device according to certain embodiments of the present invention, the above-described light emitting device provided with the recess in the resin member and the space defined by the upper portion of the metal layer which surrounds at least a portion of the recess can be manufactured.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are schematic diagrams showing a structure of a light emitting device according to an embodiment of the present invention, in which FIG. 1A is a perspective view and FIG. 1B is a plan view.

FIGS. 2A and 2B are schematic diagrams showing a structure of a light emitting device according to an embodiment of the present invention, in which FIG. 2A is a cross-sectional view taken along line II-II in FIG. 1B, and FIG. 2B is a cross-sectional view taken along line in FIG. 1B.

FIGS. 3A and 3B are schematic diagrams showing a structure of a light emitting device according to an embodiment of the present invention, in which FIG. 3A is a cross-sectional view taken along line IV-IV in FIG. 1B, and FIG. 3B is a cross-sectional view taken along line V-V in FIG. 1B.

FIG. 4 is a schematic diagram showing a structure of a light emitting device according to an embodiment of the present invention, showing a cross-sectional view taken along line I-I in FIG. 1B.

FIGS. 5A and 5B are schematic plan views showing a layer structure of a light emitting device according to an embodiment of the present invention, in which FIG. 5A shows an arrangement region of a p-type semiconductor layer and a cover electrode, and FIG. 5B shows an arrangement region of a light-reflecting electrode.

FIGS. 6A and 6B are schematic plan views showing a layer structure of a light emitting device according to an embodiment of the present invention, in which FIG. 6A shows an arrangement region of an insulating film, and FIG. 6B shows an arrangement region of an n-side electrode and a p-side electrode.

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FIG. 7 is a schematic plan view showing a layer structure of a light emitting device according to an embodiment of the present invention, showing an arrangement region of a resin member and a metal layer.

FIG. 8 is a schematic diagram for illustrating mounting of a light emitting device according to an embodiment of the present invention on a mounting substrate, showing a cross-sectional view taken along line V-V in FIG. 1B.

FIG. 9 is a flowchart showing a flow of a method of manufacturing a light emitting device according to an embodiment of the present invention.

FIGS. 10A to 10E are schematic cross-sectional views showing a portion of steps of manufacturing a light emitting device according to an embodiment of the present invention, in which FIG. 10A illustrates forming a semiconductor stacked-layer body, FIG. 10B illustrates forming a light-reflecting electrode, FIG. 10C illustrates forming a cover electrode, FIG. 10D illustrates exposing a n-type semiconductor layer, and FIG. 10E illustrates forming an insulating film.

FIGS. 11A and 11B are schematic diagrams showing a step of forming a pad electrode in manufacturing of a light emitting device according to an embodiment of the present invention, in which FIG. 11A is a plan view, and FIG. 11B is a cross-sectional view taken along line I-I in FIG. 11A.

FIGS. 12A and 12B are schematic diagrams showing a step of forming a mask in manufacturing of a light emitting device according to an embodiment of the present invention, in which FIG. 12A is a plan view, and FIG. 12B is a cross-sectional view taken along line I-I in FIG. 12A.

FIGS. 13A and 13B are schematic cross-sectional views showing a step of forming a resin member in manufacturing of a light emitting device according to an embodiment of the present invention, in which FIG. 13A shows a sub-step of coating, and FIG. 13B shows a sub-step of exposing and developing.

FIGS. 14A and 14B are schematic cross-sectional views showing portion of steps of manufacturing a light emitting device according to an embodiment of the present invention, in which FIG. 14A shows a step of forming a metal layer, and FIG. 14B shows a step of removing a mask.

FIGS. 15A and 15B are schematic diagrams showing a step of separating a pad electrode in manufacturing of a light emitting device according to an embodiment of the present invention, in which FIG. 15A is a plan view, and FIG. 15B is a cross-sectional view taken along line I-I in FIG. 15A.

FIG. 16 is a schematic cross-sectional view illustrating removing a growth substrate in manufacturing of a light emitting device according to an embodiment of the present invention.

FIGS. 17A and 17B are schematic diagrams showing a structure of a light emitting device according to a variation of an embodiment of the present invention, in which FIG. 17A is a perspective view, and FIG. 17B is a cross-sectional view taken along line VI-VI in FIG. 17A.

#### DETAILED DESCRIPTION

A light emitting device and a method of manufacturing the same according to embodiments of the present invention will be described below. Note that, because the drawings referred to in the following description schematically show the present invention, the scale, intervals, or positional relationship of the constituent elements may be exaggerated, or portions of the constituent elements may not be shown. Also, the sizes and/or intervals of the constituent elements may not be the same among corresponding perspective, plan

view, and cross-sectional views. Also, in the following description, the same designations or the same reference numerals denote the same or similar members, and detailed descriptions thereof may be appropriately omitted.

Further, in connection with the light emitting device according to embodiments of the present invention, the terms such as “top/upper”, “bottom/lower”, “left”, and “right”, may be replaced by one another according to the situation. In the present specification, the terms such as “top/upper” and “bottom/lower” are used to illustrate a relative positional relationship between the components illustrated in the accompanying drawings and are not intended to specify absolute positions unless otherwise stated.

#### Structure of Light Emitting Device

First, with reference to FIG. 1A to FIG. 7, a structure of a light emitting device according to an embodiment of the present invention will be described.

Cross-sectional views of FIG. 2A to FIG. 3B respectively schematically show the cross sections taken along line II-II to line V-V in a plan view of FIG. 1B, while maintaining relative scale in the plan view. The cross-sectional view of FIG. 4 schematically shows the cross section taken along line I-I in the plan view of FIG. 1B. Positions A1 to A6 on line I-I in FIG. 1B correspond to positions A1 to A6 indicated by arrows in FIG. 2A to FIG. 4. The cross section taken along line I-I is the same cross section taken along a line connecting between position A1 and position A6. Thus, the cross-sectional view shown in FIG. 4 is formed by combining the cross sections of FIG. 2A to FIG. 3B as appropriate. Further, in order to show the substantial portion of the cross-sectional structure, the relative scale in the cross-sectional view of FIG. 4 is partially reduced from the relative scale (the widths of members) in the plan view of FIG. 1B. That is, the relative scale is not identical between FIG. 4 and FIG. 1B. Further, the cross-sectional views of FIG. 10A to FIG. 16 for illustrating the steps of manufacturing also respectively correspond to the cross section taken along line I-I in the plan view of FIG. 1B, as a same manner in FIG. 4, unless otherwise stated. Further, in FIG. 5A to FIG. 7, in order to illustrate the stacked layer structure of a light emitting device 100 according to the present embodiment, the arrangement region of each layer in a plan view is shown by hatching or shading.

As shown in FIG. 1A to FIG. 7, the outer shape of the light emitting device 100 according to the present embodiment is approximately rectangular parallelepiped-shaped. The light emitting device 100 is a CSP that includes a structure that includes a semiconductor light emitting element 1 with an LED (light emitting diode) structure from which a growth substrate has been removed (hereinafter referred to as the “light emitting element” as appropriate), and a support body 2 disposed on the one surface side of the light emitting element 1. Although the details will be illustrated below, the light emitting device 100 is a WCSP formed at a wafer level (a CSP obtained by wafer level processing).

On the one surface (the upper surface in FIG. 2A to FIG. 4) side of the light emitting element 1, an n-side electrode 13 and a p-side electrode 15 are disposed, and the support body 2 made of a resin member 21 is disposed. Further, in the resin member 21, as internal wirings, a metal layer (an n-side metal layer) 31n and a metal layer (a p-side metal layer) 31p are disposed. The metal layer 31n is electrically connected to the n-side electrode 13, and the metal layer 31p is electrically connected to the p-side electrode 15. The upper surface of each of the metal layers 31n and 31p exposed from the resin member 21 serves as the mounting surface for

electrically connecting to the outside. The lower surface side of the light emitting element 1 serves as the light extraction surface. Further, the resin member 21 defines bowl-like recesses 21c at three locations in the upper surface, and is provided with a step difference 21b at a lower end side of the outer side surface, such that the lower outer edge is inward of the upper outer edge in a plan view. Also, the upper portion of each of the metal layers 31n and 31p are projected further than the upper surface of the resin member 21. Still further, the upper portion of each of the metal layers 31n and 31p is disposed to surround, in an approximately C-shaped manner in a plan view, one of the recess portions 21c formed at the upper surface of the resin member 21. Accordingly, recesses 32n and 32p are respectively defined in a center of the upper portions of the approximately C-shaped metal layers 31n and 31p.

Although a growth substrate 11 (see FIG. 10A) used in forming a semiconductor stacked-layer body 12 has been removed from the light emitting element 1, the light emitting element 1 may include the growth substrate 11 as it is or having its thickness reduced by polishing. Further, on the back surface side of the semiconductor stacked-layer body 12 from which the growth substrate 11 has been removed, or on the back surface side of the growth substrate 11, a phosphor layer which contains a phosphor may be disposed.

Next, each member of the light emitting device 100 will be described in detail below. The light emitting element 1 has a rectangular plate-like shape in a plan view, and is a face down type LED chip, i.e., the n-side electrode 13 and the p-side electrode 15 are disposed on the one surface side of the light emitting element 1.

The light emitting element 1 includes the semiconductor stacked-layer body 12 in which an n-type semiconductor layer 12n and a p-type semiconductor layer 12p are stacked. The semiconductor stacked-layer body 12 emits light upon supplying electric current between the n-side electrode 13 and the p-side electrode 15. Preferably, an active layer 12a is disposed between the n-type semiconductor layer 12n and the p-type semiconductor layer 12p.

As shown in FIGS. 1B, 2A, 3A and 3B, in the semiconductor stacked-layer body 12, regions where the p-type semiconductor layer 12p and the active layer 12a partially do not exist, that is, regions being recessed in the surface of the p-type semiconductor layer 12p, are formed (such regions are referred to as “step difference 12b”). The light emitting element 1 is provided with a circular step difference 12b at three locations in a plan view. The bottom surface of each step difference 12b is defined in the n-type semiconductor layer 12n, and through the opening 16n of the insulating film 15 at a portion of the bottom surface of the step difference 12b, the n-type semiconductor layer 12n and the n-side electrode 13 are electrically connected.

Further, along the outer periphery of the semiconductor stacked-layer body 12, a step difference 12c is defined in which the p-type semiconductor layer 12p and the active layer 12a are not present. The step difference 12c is formed at the boundary region (dicing street) which is a region along a boundary line 40 (see FIG. 10D) of the light emitting element 1 in the wafer state.

Further, the side surface being the outer edge of the semiconductor stacked-layer body 12 in a plan view, that is, the side surface being the outer edge of the n-type semiconductor layer 12n, is covered by none of the insulating film 16 and the resin member 21. In the step of singulating (S113) (see FIG. 9) which is the final step in the process of manufacturing the light emitting device 100 in the wafer level processing, the semiconductor stacked-layer body 12 is

divided, and the surface formed by such division becomes the side surface being the outer edge in a plan view. Accordingly, in the singulated light emitting device **100**, the side surface being the outer edge of the semiconductor stacked-layer body **12** is exposed.

Further, as shown in FIG. **1A** to FIG. **5B**, on substantially the entire surface of the upper surface of the p-type semiconductor layer **12p** of the semiconductor stacked-layer body **12**, a full-surface electrode **14** in which a light-reflecting electrode **14a** and a cover electrode **14b** are stacked is disposed. That is, in FIG. **5A**, a region hatched by diagonal lines is the region where the p-type semiconductor layer **12p** and the cover electrode **14b** are disposed. Further, the light-reflecting electrode **14a** has its upper and side surfaces covered by the cover electrode **14b**, and as shown by hatched in FIG. **5B** in a plan view, disposed on an inner region that is included in the region where the cover electrode **14b** is disposed.

Further, as shown in FIG. **1A** to FIG. **4** and FIG. **6A**, the insulating film **16** is disposed at the upper and side surfaces of the full-surface electrode **14** and the upper and side surfaces of the semiconductor stacked-layer body **12** (the region shaded by dots in FIG. **6A**). The insulating film **16** has openings **16n** at the bottom surface of the step differences **12b**, and openings **16p** over a portion of the cover electrode **14b**. The openings **16n** are defined in a circular shape in each of the bottom surfaces of the step differences **12b** formed at three portions. Further, the openings **16p** are circularly formed at four locations over the cover electrode **14b**. Still further, although the insulating film **16** also has an opening at the bottom surface of the step difference **12c**, the insulating film **16** may cover the entire upper surface of the n-type semiconductor layer **12n** to the end portion without having the opening.

Further, as shown in FIG. **1A** to FIG. **4** and FIG. **6B**, the p-side electrode **15** being the p-side pad electrode of the light emitting element **1** is electrically connected to the cover electrode **14b** at the openings **16p**. The p-side electrode **15** is formed at the upper surface of the cover electrode **14b** on the left region in FIG. **6B** via the insulating film **16**. Further, the p-side electrode **15** is formed to further extend to portion of the side and bottom surfaces of the step difference **12c** (near the center of the upper side in FIG. **6A**), via the insulating film **16**. Still further, the n-side electrode **13** being the n-side pad electrode of the light emitting element **1** is electrically connected to the n-type semiconductor layer **12n** at the openings **16n**. The n-side electrode **13** is formed to extend to the bottom and side surfaces of the step differences **12b**, to the upper and side surfaces of the cover electrode **14b** except for the region where the p-side electrode **15** is disposed and the nearby region, and to the side and bottom surfaces of the step difference **12c**, via the insulating film **16**, respectively. That is, in the light emitting element **1**, both the n-side electrode **13** and the p-side electrode **15** are disposed on the one surface side of the semiconductor stacked-layer body **12**. Further, in this manner, since the n-side electrode **13** and/or the p-side electrode **15** are widely provided at the upper and side surfaces of the light emitting element **1**, heat can be effectively transferred to the resin member **21** of the support body **2**, which will be described later. Thus, the heat releasing property of the light emitting device **100** can be improved.

For the semiconductor stacked-layer body **12** (the n-type semiconductor layer **12n**, the active layer **12a**, and the p-type semiconductor layer **12p**),  $\text{In}_X\text{Al}_Y\text{Ga}_{1-X-Y}\text{N}$  ( $0 \leq X$ ,  $0 \leq Y$ ,  $X+Y < 1$ ) or the like is suitably used. The semiconductor layers may each have a single-layer structure, or have a

stacked-layer structure or a superlattice structure made of layers having different compositions and thicknesses. In particular, the active layer **12a** preferably has a single quantum well structure or a multiple quantum well structure which is made of stacked layers of thin layers; each can produce quantum effect.

The full-surface electrode **14** is to serve as a current diffusion layer and a reflective layer, and has a stacked-layer configuration that includes the light-reflecting electrode **14a** and the cover electrode **14b** being stacked. The light-reflecting electrode **14a** is disposed so as to cover substantially the entire upper surface of the p-type semiconductor layer **12p**. Further, the cover electrode **14b** is disposed so as to entirely cover the upper and side surfaces of the light-reflecting electrode **14a**. The light-reflecting electrode **14a** is an electrically conductive layer provided so that the current supplied via the cover electrode **14b** and the p-side electrode **15** disposed on a portion of the upper surface of the cover electrode **14b** can be diffused evenly over the entire p-type semiconductor layer **12p**. The light-reflecting electrode **14a** has good light reflectivity, and functions also as a light-reflecting layer so that the light emitted by the light emitting element **1** is reflected in a lower direction, i.e., toward the light extraction surface.

The light-reflecting electrode **14a** may be made of a metal material having good electrical conductivity and light reflectivity. In particular, as a metal material to exhibit good light reflectivity in the visible light region, Ag, Al or an alloy whose main component is one or more of those metals can be suitably used. Further, the light-reflecting electrode **14a** may be made of a single layer of such metal materials, or may have a stacked-layer of such metal materials.

Further, the cover electrode **14b** is a barrier layer to prevent migration of the metal material used for the light-reflecting electrode **14a**. In the case where Ag or an alloy whose main component is Ag that tends to experience migration is used as the light-reflecting electrode **14a**, it is preferable to provide the cover electrode **14b**. The cover electrode **14b** may be made of a metal material having good electrical conductivity and barrier property, and for example, Al, Ti, W, Au, or an AlCu alloy may be used. The cover electrode **14b** may be made of a single layer of such metal materials, or may have a stacked-layer of such metal materials.

The n-side electrode **13** is electrically connected to the n-type semiconductor layer **12n** through the three openings **16n** defined in the insulating film **16** at the bottom surface of the step differences **12b**. In this manner, with connecting the n-side electrode **13** to the n-type semiconductor layer **12n** at portions provided in a wide area, the current supplied via the n-side electrode **13** can be evenly diffused to the n-type semiconductor layer **12n**. Accordingly, the light emission efficiency can be improved. In a plan view shown in FIG. **1B**, for the sake of convenience, the arrangement region of the cover electrode **14b** is shown in conformity to the arrangement region of the p-type semiconductor layer **12p**, but the cover electrode **14b** is disposed slightly inward of the p-type semiconductor layer **12p**. This is similar in the drawings for the steps of manufacturing to be illustrated below. The p-side electrode **15** is electrically connected to the cover electrode **14b** at the four openings **16p** defined in the insulating film **16** which is disposed on the upper surface of the cover electrode **14b**. As shown in FIG. **6A**, the metal layer **31n** having an approximately C-shape in a plan view is disposed on the upper surface of the n-side electrode **13** so as to be electrically connected to the n-side electrode **13**. The metal layer **31p** having an approximately C-shape in a

plan view is disposed on the upper surface of the p-side electrode **15** so as to be electrically connected to the p-side electrode **15**.

The n-side electrode **13** and the p-side electrode **15** may be made of a metal material. For example, a single metal such as Ag, Al, Ni, Rh, Au, Cu, Ti, Pt, Pd, Mo, Cr, or W or an alloy whose main component is one or more of those metals can be suitably used. In the case of using an alloy, for example, an AlSiCu alloy (ASC) which contains a non-metal element such as Si as its composition element may also be employed. Further, the n-side electrode **13** and the p-side electrode **15** may be made of a single layer of such metal materials, or may have a stacked-layer of such metal materials. The stacked-layer structure may be, for example, Ti/ASC/Ni or Ti/ASC/Pd, in order from the semiconductor stacked-layer body **12** side.

The insulating film **16** is a coating film having an insulating property and coating the upper and side surfaces of the semiconductor stacked-layer body **12** and the upper and side surfaces of the full-surface electrode **14**. The insulating film **16** functions as the protective film and the antistatic film of the light emitting element **1**. Further, the n-side electrode **13** and the p-side electrode **15** are complementarily formed over the wide area of the upper surface of the insulating film **16**. The insulating film **16** may be made of a metal oxide or a metal nitride. For example, at least one type of oxide or nitride selected from the group consisting of Si, Ti, Zr, Nb, Ta, and Al can be suitably used. Further, the insulating film **16** may be made of at least two types of light-transmissive dielectrics differing in index of refraction being stacked to form a DBR (Distributed Bragg Reflector) film.

The light emitting element **1** shown in FIG. 1A to FIG. 4 is an example, and the present invention is not limited thereto. The light emitting element **1** has the n-side electrode **13** and the p-side electrode **15** disposed on a first surface side of the semiconductor stacked-layer body **12**; the arrangement region of the step differences **12b**, the n-side electrode **13** and the p-side electrode **15** can be determined as appropriate. Further, the n-type semiconductor layer **12n** and the n-side electrode **13** may be electrically connected to each other at the step difference **12c**, in place of or in addition to the step differences **12b**.

The support body **2** has a rectangular shape in a plan view which is a substantially same shape as the outer shape of the light emitting element **1**, and is disposed so as to be bonded to the surface of the light emitting element **1** where the n-side electrode **13** and the p-side electrode **15** are arranged. The support body **2** is a reinforcing member for mechanically supporting the structure of the light emitting element **1** from which the growth substrate **11** (see FIG. 10A) has been removed. The support body **2** is structured by the resin member **21** which includes the metal layers **31n** and **31p**. In a plan view, the light emitting device **100** shown in FIG. 1A to FIG. 4 has the support body **2** enclosed in the light emitting element **1**, but the support body **2** and the light emitting element **1** may be overlapping with each other, or the support body **2** may enclose the light emitting element **1**.

The resin member **21** is a base material serving as the reinforcing member of the light emitting element **1**. In a plan view shown in FIG. 1A to FIG. 4 and FIG. 7, the resin member **21** has a substantially similar shape to the outer shape of the light emitting element **1** (the region shaded by dots in FIG. 7), and the resin member **21** is provided with the step difference **21b** at its side surface such that the lower portion is enclosed in the upper portion. Further, the resin member **21** defines three bowl-shaped recesses **21c** in its upper surface, which are the regions above the step differ-

ences **12b** of the semiconductor stacked-layer body **12**. In the present specification, the term "above" used in a positional relationship indicates a higher position within the outer periphery of a particular portion. The recesses **21c** are defined corresponding to the shape of the step differences **12b**, at the time of forming the resin member **21** on the upper surface of the light emitting element **1**. Further, the resin member **21** defines openings **21n** and **21p** each made in an approximately C-shape in a plan view, and, the metal layers **31n** and **31p** of internal wirings are disposed penetrating in the thickness direction in the openings **21n** and **21p**. The metal layers **31n** and **31p** are disposed to surround at least a portion of different recesses **21c** respectively, that is, in a plan view, the metal layers **31n** and **31p** are each disposed in an approximately C-shape around respective recesses **21c**. The metal layers **31n** and **31p** are disposed so that the upper portions of the metal layers **31n**, **31p** projected from the upper surface of the resin member **21**, that is, the regions shown by hatched with diagonal lines in FIG. 7 in a plan view, are extended on portions of the upper surface of the resin member **21** that surround the opening edge of the openings **21n** and **21p**, that is the region represented by broken lines in the region shown by hatched with diagonal lines in FIG. 7.

The shape of the recesses **21c** is not particularly limited, and the shape in a plan view may be rectangular or polygonal. The width (the diameter in the case of a circular shape) of the recesses **21c** in a plan view or the depth at the center portion thereof is not particularly limited, but the width is preferably about 20  $\mu\text{m}$  to about 60  $\mu\text{m}$ , and the depth at the center portion thereof is preferably about 3  $\mu\text{m}$  to about 5  $\mu\text{m}$ . Defining the recesses **21c** with such a size allows excessive solder to be effectively held in the recesses **21c** at the time of mounting.

Further, the recesses **21c** are respectively defined in the regions above the step differences **12b** of the semiconductor stacked-layer body **12**, so that the load acting on the light emitting device **100** at the time of mounting the light emitting device **100** can be prevented from directly acting on the step differences **12b**. That is, the load acting on the insulating film **16** and n-side electrode **13** that covers the side surfaces of the step differences **12b** at the time of mounting can also be reduced. Accordingly, damage to the insulating film **16** and the n-side electrode **13** which may cause, for example, occurrence of leakage current can be suppressed. As a result, the reliability of the light emitting device **100** can be improved.

The resin material of the resin member **21** may be any material known in the art. Preferably, a photosensitive material used as photoresist is used. Through the use of a photosensitive resin material, the resin member **21** can be patterned by using photolithography method.

Further, in order to enhance thermal conductivity, the resin member **21** may contain a thermally conductive member, e.g., granular carbon black or aluminum nitride (AlN). In order to efficiently extract the light from the light emitting element **1** from the lower surface side (the light extraction surface side), the resin member **21** may contain a light-reflecting filler, e.g.,  $\text{TiO}_2$ ,  $\text{SiO}_2$ , or  $\text{Al}_2\text{O}_3$ . In the case where the resin member **21** contains a light-reflecting filler, the full-surface electrode **14** of the light emitting element **1** may be formed using a light-transmissive electrically conductive material such as indium tin oxide (ITO) or indium zinc oxide (IZO).

The lower limit of the thickness of the resin member **21** can be determined so that the resin member **21** has a sufficient mechanical strength as the reinforcing member of



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the light emitting element **1** in the case where the growth substrate **11** (see FIG. 10A) has been removed or the thickness thereof has been reduced. For example, in view of the reinforcing member, the thickness of the resin member **21** is preferably about 30  $\mu\text{m}$  or more, and more preferably about 90  $\mu\text{m}$  or more. The upper limit of the thickness of the resin member **21** can be determined considering the proportion of the volume of metal in the resin member **21** and the amount of heat generated from the light emitting element **1** to obtain sufficient heat dissipation. For example, about 150  $\mu\text{m}$  or less is preferable and about 120  $\mu\text{m}$  or less is more preferable.

The metal layer (the n-side metal layer) **31n** is disposed penetrating the resin member **21** in the thickness direction. The lower surface of the metal layer **31n** is connected to the n-side electrode **13** of the light emitting element **1**, and the upper surface of the metal layer **31n** serves as the mounting surface for external connection. That is, the metal layer **31n** is an n-side internal wiring, and also serves as an n-side external connection electrode. Further, the upper portion of the metal layer **31n** is projected from the upper surface of the resin member **21**, and in a plan view, formed into an approximately C-shape so as to surround one of the recesses **21c** defined in the upper surface of the resin member **21**. That is, as seen from the upper surface side of the metal layer **31n**, the recess **21c** which is the recess **32n** which is defined by the upper surface of the resin member **21** as a bottom surface and the upper portion of the metal layer **31n** protruding from the resin member **21** as a side wall which at least partially surround the recess **32n**, and the recess **21c** defined in the upper surface of the resin member **21** is located in the recess **32n**.

The metal layer (the p-side metal layer) **31p** is disposed penetrating the resin member **21** in the thickness direction. The lower surface of the metal layer **31p** is connected to the p-side electrode **15** of the light emitting element **1**, and the upper surface of the metal layer **31p** serves as the mounting surface for external connection. That is, the metal layer **31p** is a p-side internal wiring, and also serves as a p-side external connection electrode. Further, the upper portion of the metal layer **31p** is projected from the upper surface of the resin member **21**, and in a plan view, formed into an approximately C-shape so as to surround one of the recesses **21c** defined in the upper surface of the resin member **21**. That is, as seen from the upper surface of the metal layer **31p**, the recess **32p** which is defined by the upper surface of the resin member **21** as a bottom surface and the upper portion of the metal layer **31p** projecting from the resin member **21** as a side wall which at least partially surround the recess **32p**, and the recess **21c** defined in the upper surface of the resin member **21** is located in the recess **32p**.

Further, the upper portions of the metal layers **31n** and **31p** projecting from the resin member **21** are respectively arranged in an approximately C-shape or an approximately U-shape in a plan view so as to surround the recess **21c** with an opening. Thus, with the use of the load perpendicularly acting on the light emitting device **100** at the time of mounting the light emitting device **100**, an excessive bonding member can be released in the opening direction. Accordingly, the range of appropriate amount of the bonding member supplied in a step of mounting, i.e., the allowable range, can be extended to greater supply amount. Further, the shape of the recesses **32n** and **32p** in a plan view is not limited to a shape with a single opening such as an approximately C-shape or an approximately U-shape and a shape with two or more openings can also be employed.

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The difference in height between the upper surfaces of the metal layers **31n** and **31p** and the upper surface of the resin member defining the opening edge of the recess **21c** of the resin member **21**, that is, the depth of the recesses **32n** and **32p** of the metal layers **31n** and **31p** as seen from the upper surface of the metal layers **31n** and **31p** is preferably about 5  $\mu\text{m}$  to about 50  $\mu\text{m}$ , and more preferably about 10  $\mu\text{m}$  to about 45  $\mu\text{m}$ . Thus, during the mounting process, excessive solder can be effectively kept in the recess portions **32n** and **32p**.

Further, in the present embodiment, the upper surfaces of the metal layers **31n** and **31p** are respectively formed to be flat, but is not limited thereto, the upper surfaces may be formed with recesses and projections. In the case where the upper surfaces of the metal layers **31n** and **31p** are formed with recesses and projections, the height from the upper surface of the resin member **21** to the top of the projections is preferably within the range described above.

Further, in the example shown in FIG. 1B, the metal layers **31n** and **31p** are respectively formed in an approximately C-shape with an opening (the right side in FIG. 1B) in a plan view to surround the recess **21c** of the resin member **21**, but it is not limited thereto. The metal layers **31n** and **31p** may have, in a plan view, a shape with two or more openings that surrounds the recess **21c**. Alternatively, the upper portions of the metal layers **31n** and **31p** may be formed to surround the recess portion **21c** without the opening.

Further, the metal layers **31n** and **31p** also function as the heat transferring paths for releasing the heat generated by the light emitting element **1**. Accordingly, the proportion of the volume of metal with respect to the resin member **21** is preferably greater.

The metal layers **31n** and **31p** may be suitably made of a metal such as Cu, Au, Al or the like. The metal layers **31n** and **31p** may also have a stacked-layer structure using a plurality of types of metal. Particularly, the uppermost surfaces of the metal layers **31n**, **31p** that serve as the mounting surface are preferably made of Au so as to prevent corrosion and to enhance the bonding with the mounting substrate, via an Au alloy-based adhesive member such as an Au—Sn eutectic solder. Further, in the case where the lower layer portions of the metal layers **31n** and **31p** are made of a metal other than Au, e.g., Cu or Al, the upper layer portion may have a stacked-layer structure such as Ni/Au or Ni/Pd/Au, in order to improve adhesion to Au. Further, a solder such as Sn—Cu or Sn—Ag—Cu can be employed as the adhesive member. In this case, the uppermost layers of the metal layers **31n** and **31p** are preferably made of a material which allows for good adhesion to the adhesive material that is used. The metal layers **31n** and **31p** can be formed by using an electroplating method. The method of forming the metal layers **31n** and **31p** will be described in detail below.

## Mounting of Light Emitting Device

Next, with reference to FIG. 8, a description will be given of preventing a solder from being squeezed out when the light emitting device **100** is mounted on the mounting substrate. FIG. 8 shows a cross section of the light emitting device **100** taken along line V-V in FIG. 1B, that is, FIG. 8 shows a cross section of the n-side mounting surface shown in FIG. 3B. The configuration of the p-side mounting surface (a cross section taken along line IV-IV in FIG. 1B) of the light emitting device **100** is similar to that of the n-side mounting surface, so that the description thereof will be appropriately omitted.

As shown in FIG. 8, the light emitting device **100** is mounted in a face down manner, so that the mounting surface of a mounting substrate **91** provided with a wiring

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pattern 92 and the surface provided with the support body 2; that is, the surfaces of the metal layers 31n and 31p exposed outside the resin member 21, are facing each other. Thus, the light emitting device 100 in FIG. 8 is upside-down as compared to FIG. 3B. The light emitting device 100 is mounted on the mounting substrate 91 by using a reflow method, using an adhesive member 93 such as an Au—Sn eutectic solder.

In the step of mounting, the adhesive member 93 that has already been applied between the metal layer 31n and the wiring pattern 92 is melted, and then allowed to cool. Thus, the metal layer 31n and the wiring pattern 92 are strongly bonded to each other.

In this step, when the adhesive member 93 is melted and is in a liquid state, an excessive adhesive member 93 may be squeezed out from between the metal layer 31n and the wiring pattern 92. A large portion of the squeezed out excessive adhesive member 93 can be held in the recess 32n of the metal layer 31n that serves as the external connection electrode, and further held in the recess 21c of the resin member 21, thus allowing a reduction in the amount of the adhesive member 93 squeezed out beyond the outer edge of the region where the metal layer 31n is arranged in a plan view. Accordingly, the adhesive member 93 can be prevented from rising along the side surface of the resin member 21. As a result, the light emitting device 100 can be mounted on the mounting substrate 91 with high reliability.

Further, the step difference 21b formed at the side surfaces of the resin member 21 increases the distance along the surfaces from the lower end of the resin member 21 (upper end in FIG. 3B) to the light emitting element 1. Also, the adhesive member 93 is retained in the step difference 21b. Thus, the adhesive member 93 rises along the side surfaces of the resin member 21 can be prevented from easily reaching the light emitting element 1. The distance between the upper side surface and the lower side surface of the step difference 21b in a plan view (the difference in the positions of the side surfaces in a lateral direction in FIG. 8) is preferably about 1 μm to about 10 μm, and more preferably about 3 μm to about 6 μm. With this arrangement, the rising of the solder can be more effectively blocked.

#### Operation of Light Emitting Device

Next, with reference to FIG. 1A to FIG. 4 and FIG. 8, operation of the light emitting device 100 will be described. In the light emitting device 100, upon connecting the metal layers 31n and 31p, which are electrodes for external connection, to an external power supply via the mounting substrate 91, the current is supplied between the n-side electrode 13 and the p-side electrode 15 of the light emitting element 1. Then, upon being supplied with the current between the n-side electrode 13 and the p-side electrode 15, the active layer 12a of the light emitting element 1 emits light.

The light emitted by the active layer 12a of the light emitting element 1 propagates inside the semiconductor stacked-layer body 12, and is emitted from the lower surface (the upper surface in FIG. 8) or the side surfaces of the light emitting element 1, which is then extracted to the outside. The light that propagates in the upward direction (the downward direction in FIG. 8) inside the light emitting element 1 is reflected by the light-reflecting electrode 14a, and is emitted from the lower surface (the upper surface in FIG. 8) of the light emitting element 1, which is then extracted to the outside.

#### Method of Manufacturing Light Emitting Device

Next, with reference to FIG. 9, a method of manufacturing the light emitting device 100 shown in FIG. 1A to FIG. 4

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will be described. As shown in FIG. 9, the method of manufacturing the light emitting device 100 includes a step of forming a semiconductor stacked-layer body (S101), a step of forming a light-reflecting electrode (S102), a step of forming a cover electrode (S103), a step of exposing an n-type semiconductor layer (S104), a step of forming an insulating film (S105), a step of forming a pad electrode (S106), a step of forming a mask (S107), a step of forming a resin member (S108), a step of forming a metal layer (S109), a step of removing the mask (S110), a step of separating a pad electrode (S111), a step of removing a growth substrate (S112), and a step of singulating (S113), which are performed in this order. Further, the step of forming a semiconductor stacked-layer body (S101) to the step of forming the pad electrode (S106) are included in a step of providing a wafer, in which the light emitting elements 1 in a wafer state is provided, and the step of forming a light-reflecting electrode (S102) and the step of forming the cover electrode (S103) are included in a step of forming a full-surface electrode.

In the following, with reference to FIG. 10A to FIG. 16 (and to FIG. 1A to FIG. 7 and FIG. 9 as appropriate), each step will be described in detail. In FIG. 10A to FIG. 16, the shape, size, and positional relationship of the constituent elements may be simplified or exaggerated as appropriate. Further, in the steps of manufacturing the light emitting device 100 in wafer unit, the steps are performed in the state where a number of light emitting elements are aligned two-dimensionally. In FIG. 10A to FIG. 16, the cross-sectional views respectively show a single light emitting element and the plan views respectively show two light emitting elements directly adjacent to each other along the longitudinal side, among the arrays of a number of the light emitting elements. The cross-sectional views shown in FIG. 10A to FIG. 16 respectively correspond to the cross section taken along line I-I in FIG. 1B, similarly to the cross-sectional view of FIG. 4.

In the method of manufacturing the light emitting device according to an embodiment of the present invention, first, the step of providing a wafer is performed, in which a plurality of light emitting elements 1 are arrayed on a single growth substrate 11. As described above, the step of providing the wafer may include the step of forming the semiconductor stacked-layer body (S101), the step of forming the light-reflecting electrode (S102), the step of forming the cover electrode (S103), the step of exposing the n-type semiconductor layer (S104), the step of forming the insulating film (S105), and the step of forming the pad electrode (S106).

First, in the step of forming the semiconductor stacked-layer body (S101), as shown in FIG. 10A, on the upper surface of the growth substrate 11 made of sapphire or the like, a semiconductor stacked-layer body 12 is formed by successively stacking the n-type semiconductor layer 12n, the active layer 12a, and the p-type semiconductor layer 12p, respectively using the semiconductor materials described above.

Next, in the step of forming the light-reflecting electrode (S102), as shown in FIG. 10B, the light-reflecting electrode 14a is formed at a predetermined region. The light-reflecting electrode 14a can be formed by using a lift-off method. That is, with the use of a photolithography, a resist pattern that defines openings corresponding to the regions for arranging the light-reflecting electrodes 14a is formed; then, a film of a metal material such as Ag which has good light reflectivity as described above, is disposed by using a sputtering method or a vapor deposition method on the entire upper surface of

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the wafer. With the removal of the resist pattern, the film of the metal material is patterned to form the light-reflecting electrode **14a**.

Next, in the step of forming the cover electrode (S103), as shown in FIG. 10C, the cover electrode **14b** is formed so as to cover the upper and side surfaces of the light-reflecting electrode **14a**. The cover electrode **14b** is formed such that a film of a metal material is formed over the entire upper surface of the wafer by sputtering or deposition using a predetermined metal material, then, using a photolithography method, a resist pattern is formed to cover the area for arranging the cover electrode **14b**. Then, etching is performed with the use of the resist pattern as a mask to pattern the film of the metal material. Then, the resist pattern is removed to obtain the cover electrode **14b**.

Next, in the step of exposing the n-type semiconductor layer (S104), as shown in FIG. 10D, in a portion of the semiconductor stacked-layer body **12**, the p-type semiconductor layer **12p**, the active layer **12a**, and a portion of the n-type semiconductor layer **12n** are removed by using a dry etching method. Thus, the step differences **12b** and the step difference **12c** where the n-type semiconductor layer **12n** is exposed at the respective bottom surfaces are formed. In the example shown in FIG. 10D, the full-surface electrode **14** is used as an etching mask, so that the entire region having the p-type semiconductor layer **12p** and the active layer **12a** is coated by the full-surface electrode **14**.

Next, in the step of forming the insulating film (S105), as shown in FIG. 10E, the insulating film **16** defining the openings **16n** and the openings **16p** at portions of the step differences **12b** and portions of the upper surfaces of the cover electrode **14b** is formed using a predetermined insulating material. Further, the insulating film **16** is formed to define openings also at portions of the bottom surfaces of the step differences **12c** along the boundary lines, respectively **40**. The bottom surface of each of the step differences **12c** may be entirely coated by the insulating film **16** without creating any openings. Further, the insulating film **16** can be patterned such that, after a film of the insulating material is formed over the entire upper surface of the wafer by sputtering or the like, a resist pattern with openings at predetermined regions corresponding to the openings **16n** and **16p** and the like is formed, and etching is performed on the film of the insulating material.

Next, in the step of forming the pad electrode (S106), as shown in FIGS. 11A and 11B, a metal layer **50** is formed on the insulating film **16** by using a sputtering method, for example. The metal layer **50** can be patterned by using a lift-off method, for example. The metal layer **50** is to be the n-side electrode **13** and the p-side electrodes **15** which are the pad electrodes of the light emitting element **1**. Accordingly, the metal layer **50** is connected to the n-type semiconductor layer **12n** in the openings **16n** of the insulating film **16** disposed at the region for the n-side electrode **13** (regions shown by right down hatching in FIGS. 11A and 11B). Further, the metal layer **50** is connected to the cover electrode **14b** in the openings **16p** of the insulating film **16** disposed at the region for the p-side electrode **15** (regions shown by right up hatching in FIGS. 11A and 11B).

The metal layer **50** is formed with separate portions in the region of each of the light emitting elements **1** demarcated by the boundary lines **40** so that the region to be the n-side electrode **13** and the region to be the p-side electrode **15** do not contact with each other. However, the metal layer **50** is formed to be connected to all the light emitting elements **1** that are formed in the arrays on the wafer, such that an extending portion **50a** of the metal layer **50** extended from

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the metal layer **50** to be the p-electrode **15** of a light emitting element **1** along the boundary line **40** (around the center at the top side in the longitudinal direction in FIG. 11A) is connected to the metal layer **50** to be the n-side electrode **13** of the adjacent light emitting element **1**. The metal layer **50** is used as the seed layer serving as the current path at the time of forming the metal layers **31n** and **31p** by using an electroplating method in the step of forming a metal layer (S109). In the present embodiment, the metal layer **50** to be the n-side electrode **13** and the p-side electrode **15** to be the pad electrode is formed to also serve as the seed layer for electroplating, which allows for simplifying the manufacturing.

Next, in the step of forming the mask (S107), as shown in FIGS. 12A and 12B, a mask **33** that covers the metal layer **50** formed at the step differences **12c** that are the regions along the boundary lines **40** is formed. The mask **33** may be formed using an insulating material such as a photoresist or  $\text{SiO}_2$ . The mask **33** is an insulating mask for preventing plating on the step differences **12c** that are the boundary regions in the step of forming the metal layer (S109) that is to be performed. The mask **33** is made of a material different from that of the resin member **21**, so as to be selectively removed in the step of removing the (S110) while leaving the resin member **21**. Further, the mask **33** is preferably formed lower than the upper surface of the resin member **21** (see FIG. 13A) formed in the step of forming the resin member (S108) to be performed next, and wider than the openings **21a** of the resin member **21** (see FIG. 13B). Thus, the step differences **21b** (see FIG. 14B) can be formed at the side surfaces of the resin member **21**.

Next, in the step of forming the resin member (S108), as shown in FIG. 13B, the resin member **21** is formed on the metal layer **50** by using a photolithography method. The resin member **21** defines the openings **21n** on the region to be the n-side electrode **13** of the metal layer **50** and the openings **21p** on the region to be the p-side electrode **15** of the metal layer **50**. Further, the resin member **21** defines the openings **21a** on the regions along the boundary lines **40**, so that the resin member **21** is formed for each region of the light emitting element **1**, and separated for each of the light emitting elements **1**. Further, the openings **21a** are preferably defined to be narrower than the mask **33**.

The step of forming the resin member **21** which uses a photolithography method may include sub-steps. First, as shown in FIG. 13A, a photoresist in a liquid form is evenly applied on the wafer by using a coating method such as spin coating or spraying (a step of coating). At this time, corresponding to the shape of the step differences **12b** of the semiconductor stacked-layer body **12**, concave depressions that become the recesses **21c** are created at the upper surface of the coating film at the regions above the step differences **12b**. By heating and drying (a step of curing) the coating film of the photoresist while maintaining the shapes of the concave depressions, the recesses **21c** are defined in the upper surface of the resin member **21**. Further, a step of exposing and developing is performed following the step of coating and the step of curing, thus, the openings **21n**, **21p**, and **21a** are formed as shown in FIG. 13B.

In this step, in order to form the recesses **21c**, the viscosity of the liquid photoresist is adjusted according to the shape (width, depth) of the step differences **12b**, the thickness of the resin member **21**, and the time required for heat-drying to cure the coating film. The recesses are also created in the upper surfaces of the coating film of the resin in the regions above the step differences **12c** of the semiconductor stacked-layer body **12**, respectively. In the step of forming the mask

(S107), by forming the mask **33** at the step differences **12c** with a height approximately same as the height of the upper surface of the metal layer **50** in the region where the cover electrode **14b** is arranged—that is, by forming the mask **33** so as to substantially fill the step differences **12c**—the upper surface of the resin coating film can be made approximately flat over the step differences **12c**.

Next, in the step of forming the metal layer (S109), as shown in FIG. 14A, the metal layers **31n** and **31p** are formed in the openings **21n** and **21p** of the resin member **21** by using an electroplating method. As described above, the metal layers **31n** and **31p** are grown by plating in the openings **21n** and **21p** of the resin member **21** using the metal layer **50**, which is formed to be conductive as a whole, as the seed layer which serve as the current path of electroplating. Further, in the step of forming the metal layer (S109), the resin members **21** respectively define the openings **21a** in the step differences **12c** (see FIG. 14B) which are the regions along the boundary lines **40**, but the metal layer **50** is covered with the mask **33**, so that the openings **21a** are not subjected to the plating growth. Accordingly, a thick plating layer is not formed at the boundary regions, so that unnecessary portions of the metal layer **50** can be easily removed in the step of separating pad electrode (S111) which to be executed in a later step.

In the example shown in FIG. 14A, the metal layers **31n** and **31p** are formed such that the upper portion of each of them are projected from the upper surface of the resin member **21**, and such that the projecting upper portion extends to the outside of the openings **21n** and **21p** of the resin member **21** in a plan view. This is because at the time of plating growth, the metal layers **31n** and **31p** grow also in a lateral direction from the side surfaces of the upper portion which is projecting from the upper surface of the resin member **21**.

Further, in the case where the area of the openings **21n** and **21p** is small, the upper surface of the upper portion of each of the metal layers **31n** and **31p** which are projecting from the resin member **21** may be rounded. In order to further planarize the upper surface of the metal layers **31n** and **31p**, the upper surface of the metal layers **31n** and **31p** may be planarized by grinding or polishing after electroplating.

Next, in the step of removing the mask (S110), as shown in FIG. 14B, the mask **33** is removed with the use of any appropriate solvent or agent. Thus, the metal layer **50** formed in the regions along the boundary lines **40** is exposed at the bottom surface of the openings **21a** of the resin member **21**. Further, by removing the mask **33**, the step difference **21b** is formed at the lower side surfaces of the resin member **21**.

Next, in the step of separating the pad electrode (step of separating electrode) (S111), as shown in FIGS. 15A and 15B, the metal layer **50** exposed at the bottom surface of the openings **21a** of the resin member **21** is removed by etching. Thus, the metal layer **50** is divided for each light emitting device **100**. Also, in each light emitting device **100**, the metal layer **50** is separated into the region to be the n-side electrode **13** and the region to be the p-side electrode **15**.

At the time of etching the metal layer **50**, a mask may be disposed on the upper surface of each of the metal layers **31n** and **31p** to prevent the metal layers **31n** and **31p** from being etched. Further, in the case where the metal layers **31n** and **31p** respectively have a thickness that is sufficiently greater than the thickness of the metal layer **50**, the metal layer **50** may be etched without providing the mask on the upper surface of each of the metal layers **31n** and **31p**, permitting

a reduction in the thickness of the metal layers **31n** and **31p** by approximately the thickness of the metal layer **50**.

Next, in the step of removing the growth substrate (S112), as shown in FIG. 16, the growth substrate **11** is removed by peeling off by using a laser lift-off (LLO) method or a chemical lift-off method. The step of removing the growth substrate (S112) is not an essential step, and the growth substrate **11** may not be removed. Further, in place of peeling off the growth substrate **11**, the lower surface side of the growth substrate **11** may be polished to reduce the thickness. Further, after the growth substrate **11** has been peeled off, the lower surface of the semiconductor stacked-layer body **12** may be wet-etched to form recesses-projections shape. Still further, after the growth substrate **11** has been peeled off, or without peeling the growth substrate **11** off, a phosphor layer that contains a phosphor for converting the wavelength of light emitted by the light emitting element **1** may be disposed on the lower surface side which serves as the light extraction surface of the light emitting device **100**.

Next, in the step of singulating (S113), the light emitting device **100** is singulated by cutting the wafer along the boundary lines **40** shown in FIG. 16, with the use of a dicing method, a scribing method, or the like. The side surfaces that become the outer edges of the semiconductor stacked-layer body **12** that is formed by singulating is, as shown in FIG. 2A to FIG. 4, exposed without covered with the insulating film **16** and the resin member **21**. The resin member **21** is formed with openings along the boundary lines **40**, so that the resin member **21** is separated for each light emitting device **100**, thus, singulating can be easily performed by simply cutting the semiconductor stacked-layer body **12**.

#### Variation of Light Emitting Device

Next, with reference to FIGS. 17A and 17B, a light emitting device according to a variation of an embodiment of the present invention will be described. The plan view of the light emitting device **100A** is similar to the plan view of the light emitting device **100** shown in FIG. 1B. As shown in FIGS. 17A and 17B, the light emitting device **100A** according to the present variation is different in that it includes a support body **2A** in place of the support body **2** of the light emitting device **100** shown in FIG. 1A and others. More specifically, in the metal layers **31n** and **31p** of the support body **2**, the upper surfaces of the upper portions projecting from the resin member **21** are flat surfaces, while in the metal layers **31An** and **31Ap** of the support body **2A**, the upper surfaces of the upper portions have an upwardly curving convex shape, that is, a dome shape. Other structures are similar to those of the light emitting device **100** and, therefore, identical reference numerals are allotted thereto and the description thereof will not be given.

The upper surface of each of the metal layers **31An** and **31Ap** has a dome-shape. Accordingly, at the time of mounting the light emitting device **100A** by using a bonding member such as a solder, due to the dome-shape of the upper surfaces of the metal layers **31An** and **31Ap**, the bonding starts at the apex of the dome-shape and proceeds with the upper portion of each of the metal layers **31An** and **31Ap** digging into the bonding member. Thus, the light emitting device **100A** is mounted. In this manner, in the light emitting device **100A**, the flowability of the bonding member can be controlled to suppress the bonding defects due to occurrence of a void or the like. Accordingly, the bonding strength, the heat releasing property and the like of the light emitting device **100A** can be improved.

Further, in the case where an anisotropic conductive material such as an anisotropic conductive paste (ACP) or an anisotropic conductive film (ACF) is used as the bonding

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member, the upper surface of each of the metal layers **31An** and **31Ap** is formed in a dome-shape so that the apex of the dome-shape becomes a contact point. Accordingly, secure bonding with a smaller load on the light emitting device **100A** can be achieved. As a result, the load on the light emitting device **100A** at the time of mounting can be reduced.

Further, the light emitting device **100A** can be manufactured in a similar manner as the method of manufacturing the light emitting device **100** described above. That is, the metal layers **31An** and **31Ap** can be formed by electroplating in a similar manner as in the metal layers **31n** and **31p** in the step of forming the metal layer (**S109**) (see FIG. **9** and FIG. **14A**). In electroplating, metal isotropically grows from the plating growth end. Accordingly, above the upper end surface of the openings **21n** and **21p** (see FIG. **13B**) of the resin member **21**, plating growth of the metal also proceeds in the lateral direction in addition to the upward direction. Accordingly, as shown in FIG. **17A**, the upper portion of each of the metal layers **31An** and **31Ap** is formed in a dome-shape. Further, as shown in FIG. **17B**, the upper portion of each of the metal layers **31An** and **31Ap** has a semicircular or rounded shape in a cross-sectional view taken along a plane perpendicular to the extension direction of the ridge line of an approximately C-shape in a plan view. In particular, the narrower the openings **21n** and **21p** with respect to the thickness of the upper portions projecting from the upper surface of the resin member **21**, the more the center portions of the upper portions of the metal layers **31An** and **31Ap** project, resulting in an approximately a semicircular shape in a cross-sectional view. Other steps are similar to those in the method of manufacturing the light emitting device **100**, the description thereof will be appropriately omitted.

The light emitting device of the present disclosure and the method of manufacturing the same have been specifically described based on an example of a mode for carrying out the invention, the aspects of the present invention are not limited to the description thereof, and should be broadly construed based on the scope of claims. Further, it goes without saying that various changes and modifications made based on the description are also included in the gist of the present invention.

What is claimed is:

1. A light emitting device comprising:
  - an n-type semiconductor layer;
  - a p-type semiconductor layer located above the n-type semiconductor layer;
  - a step difference that extends through the p-type semiconductor layer, wherein the n-type semiconductor layer is exposed from the p-type semiconductor layer in the step difference;

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an n-side metal layer electrically connected to the n-type semiconductor layer via the step difference; and wherein, in a plan view, the n-side metal layer is located outside an outer periphery of the step difference and surrounds at least part of the step difference.

2. The light emitting device of claim **1**, wherein the n-side metal layer is located above the p-type semiconductor layer.

3. The light emitting device of claim **1**, further comprising an n-electrode that extends through the step difference and electrically connects the n-side metal layer to the n-type semiconductor layer.

4. The light emitting device of claim **3**, further comprising an insulating film that covers a lateral surface of the step difference, wherein the n-electrode covers the insulating film.

5. The light emitting device of claim **4**, wherein the insulating film is made of at least two stacked layers comprising dielectrics that differ in index of refraction.

6. The light emitting device of claim **3**, further comprising a resin member that covers at least an upper surface of the n-electrode and a lateral surface of the n-side metal layer, wherein an upper surface of the n-side metal layer is exposed from the resin member.

7. The light emitting device of claim **6**, wherein an upper portion of the n-side metal layer extends past an upper surface of the resin member.

8. The light emitting device of claim **7**, wherein a difference in height between the upper surface of the n-side metal layer and the upper surface of the resin member is in a range of 5  $\mu\text{m}$  to 50  $\mu\text{m}$ .

9. The light emitting device of claim **6**, wherein the resin member comprises a photosensitive material.

10. The light emitting device according to claim **6**, wherein the resin member has a thickness in a range of 30  $\mu\text{m}$  to 50  $\mu\text{m}$ .

11. The light emitting device of claim **1**, wherein an upper surface of the n-side metal layer is configured as a mounting surface for external connection.

12. The light emitting device of claim **1**, wherein the n-side metal layer has an approximately C-shape in a plan view.

13. The light emitting device of claim **1**, wherein the n-side metal layer has an approximately U-shape in a plan view.

14. The light emitting device according to claim **1**, wherein an upper surface of the n-side metal layer has an upwardly curved convex shape.

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